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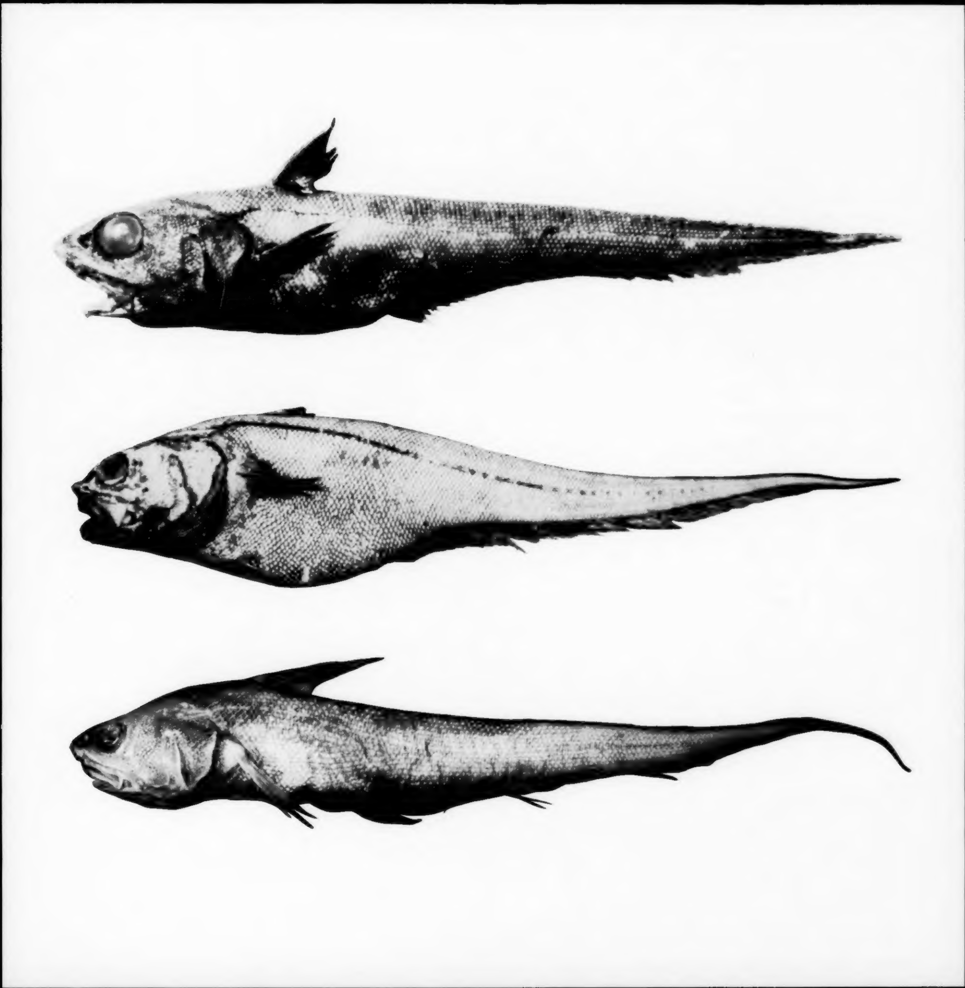
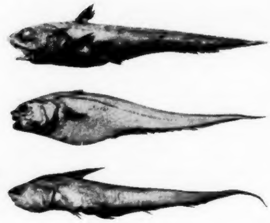


Grenadiers

Marine Fisheries
REVIEW



On the cover: From top to bottom are the Pacific grenadier, giant grenadier, and the abyssal grenadier.

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Biology and Potential Use of Pacific Grenadier, *Coryphaenoides acrolepis*, off California

TETSUO MATSUI, SUSUMU KATO and SUSAN E. SMITH

Introduction

Grenadiers (also known as rattails) belong to the family Macrouridae, and are related to the codfishes (family Gadidae). They are among the most abundant fishes in continental slope and abyssal waters worldwide. The majority of macrourid species appear to spend a good part of the time swimming near the ocean bottom, feeding on benthic and midwater organisms (Marshall and Merrett, 1977). About 300 species are known, of which 11 inhabit the deep waters off California[1].

Although abundant, grenadiers are not utilized to a great extent. The remoteness of their habitat and the small size, soft flesh, and low meat yield of many species have discouraged their commercial use. A few species with good flesh characteristics are presently sold as food fish, while others are used as fish meal and fertilizer. In the northeast and northwest Atlantic over 65,000 metric tons (t) of one species, the roundnose grenadier, *Coryphaenoides rupestris*, were caught in 1975 (FAO, 1979). Although the catch of this species has declined substantially, other species are starting to be utilized, and the total grenadier catch in 1986 was around 60,000 t, 54 percent of which was roundnose grenadier (FAO, 1988). Commercial landings in the northeast Pacific have been minimal, even though macrourids are the most abundant fishes found in trawl catches in deep waters off Oregon and Washington (Alton, 1972; Pearcy and Ambler, 1974).

Off California, at least three species of grenadier appear to be of sufficient size and abundance to warrant marketing consideration. These are the Pacific grenadier, *Coryphaenoides acrolepis*; abyssal grenadier, *C. armatus*; and giant grenadier, *Albatrossia pectoralis*. The Pacific grenadier (Fig. 1) appears to have the best potential, as the quality of its flesh is good and it is abundant off California. The largest specimen of *C. acrolepis* we have measured was over 95 cm (37 inches) in total length. It weighed 4 kg (8.8 pounds) and was taken at lat. 29°31.3′N, long. 117°12.0′W at a depth of 1,050 fm (1,920 m). This may have been an unusually large individual, as the prior known record length for the species is smaller at 87 cm or 34 inches (Rass, 1963, in Iwamoto and Stein, 1974). Pacific grenadier is a smaller species than the other two grenadiers. Its skin is dark and covered with adherent, rough scales. The long tapering tail, characteristic of all grenadiers, contributes to a low percentage yield of flesh compared with other fishes.

The giant grenadier (Fig. 2) is the largest of all of the grenadiers, reaching a length of around 150 cm (5 feet) (Iwamoto and Stein, 1974). Despite the large size and relatively high availability, its commercial potential is limited because

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ABSTRACT—Grenadiers (family Macrouridae) are the most abundant fish on most continental slope areas worldwide. Off California the Pacific grenadier, Coryphaenoides acrolepis, *occurs in relatively large numbers and may have marketing potential. This report provides information on the biology of the species and catch results from a number of scientific cruises. Catch data on several other species found together with Pacific grenadier, particularly sablefish,* Anoplopoma fimbria, *are also given. The fish were caught with a bottom trawl (15 trawls), and with free-vehicle longline gear (117 sets). The latter was a hook and line system in which the gear was dropped to the sea floor untethered to the fishing vessel, and floated to the surface, with the catch, when detachable weights were automatically released. Sablefish dominated longline catches in depths of 200-600 fm (334-1,098 m), while Pacific grenadier was most abundant between 600 and 1,000 fm (1,098-1,830 m). Best trawl catches of Pacific grenadier were made at depths between 615 and 675 fm (1,125 and 1,235 m) and at 760 fm (1,391 m).*

Ripe females were absent from our samples, but spent females were found during the entire year with highest numbers in the spring and early summer. Only one larva was found despite extensive sampling with plankton nets.

Pacific grenadier was found to have good edible qualities by a taste-test panel, although the protein content (15 percent) and flesh yield (24 percent) were significantly lower than those of other fishes. A second species, the giant grenadier, Albatrossia pectoralis, *was found to have exceptionally poor eating qualities and even lower protein content.*

Figure 1.—Pacific grenadier, *Coryphaenoides acrolepis*.

Figure 2.—Giant grenadier, *Albatrossia pectoralis*.

SIO PHOTO

Figure 3.—Abyssal grenadier, *Coryphaenoides armatus*.

Table 1.—Station data (listed by depth) for free-vehicle longline fishing conducted by SIO from 1965 to 1979.

Cruise and station	Date	Lat. (N)	Long. (W)	Depth (fm)	Time started	Hours fished	Cruise and station	Date	Lat. (N)	Long. (W)	Depth (fm)	Time started	Hours fished
MV71-I-49	5/30/71	32°22.5′	118°28.1′	153	2316	11.23	M7-1	9/13/71	32°25.2′	117°28.9′	680	2337	8.97
MF71-2	7/22/71	32°38.2′	117°57.3′	240	0919	3.37	M9-1	12/20/71	32°24.8′	117°29.0′	680	2258	13.43
MV71-I-46	5/30/71	32°06.6′	118°15.6′	293	2046	10.98	M9-2	12/20/71	32°25.1′	117°29.1′	680	2340	12.75
MV71-I-50	5/30/71	32°22.2′	118°26.4′	304	2334	10.65	M10-2	2/07/72	32°25.8′	117°28.0′	680	2348	12.27
MV71-I-57	5/31/71	32°34.7′	118°00.4′	310	2042	9.68	M10-4	2/09/72	32°26.4′	117°33.5′	680	0005	14.50
MV71-I-40	5/28/71	30°16.5′	116°09.7′	320	2132	9.63	M11-3	4/08/72	32°24.8′	117°28.6	680	2345	7.00
MV71-2	7/22/71	32°38.2′	117°57.3′	330	0928	3.28	M12-1	9/27/72	32°24.9′	117°29.0′	680	0019	9.17
MV65-III-18	9/24/65	32°44.0′	118°20.8′	337	2130	10.28	M13-1	2/28/73	32°25.5′	117°28.9′	680	2325	9.00
MV71-I-52	5/13/71	32°22.4′	118°21.3′	346	0012	11.63	MV67-IA-3	4/20/67	31°29.0′	118°01.0′	690	2025	12.58
M6-3	8/12/71	32°50.0′	117°31.4′	400	2254	8.68	SC75	—	32°34.9′	117°26.7′	700	1343	3.53
MV67-II-26	6/16/67	38°00.0′	123°31.0′	400	1915	18.92	MV71-I-47	5/30/71	32°08.8′	118°17.0′	702	2102	11.13
SC2-74	11/23/74	32°36.8′	117°28.5′	420	1044	4.40	MV71-I-11	5/20/71	28°52.7′	118°12.2′	710	1937	11.88
MV65-II-33	9/26/65	32°40.0′	118°37.5′	426	2144	10.02	S2-1-1	5/06/75	32°28.2′	118°48.5′	710	0725	5.92
M1-2	2/02/71	32°50.0′	117°31.2′	445	2204	9.93	MV65-III-37	9/22/65	32°42.6′	118°46.0′	712	0013	10.10
M5-3	7/16/71	32°50.0′	117°31.0′	445	0950	3.75	MV71-I-10	5/20/71	28°55.0′	118°11.4′	715	2006	10.63
M3-3	5/13/71	32°50.0′	117°31.0′	445	0735	4.58	M2A1	4/13/71	31°51.0′	117°11.7′	730	2153	10.32
MV71-I-24	5/25/71	28°21.8′	115°44.3′	453	2114	11.27	M2A2	4/13/71	31°51.0′	117°11.7′	730	2110	11.95
MV67-IA-22	4/26/67	28°09.0′	118°16.2′	455	0218	15.70	71RI-2	1/19/71	32°45.2′	119°26.5′	735	2110	11.58
MV71-I-16	5/23/71	29°27.5′	117°19.2′	490	2204	12.65	MV65-III-19	9/24/65	32°42.0′	118°16.0′	738	2317	9.30
M10-5	2/09/72	32°34.7′	117°26.0′	530	2140	10.33	MV65-III-26	9/25/65	32°47.6′	118°47.0′	748	1936	13.07
MV67-IA-28	4/27/67	29°26.5′	117°15.6′	536	1953	11.88	MV71-I-3	5/18/71	28°52.2′	118°12.0′	750	2106	10.04
MV65-III-24	9/25/65	32°44.5′	118°43.5′	537	1830	13.00	MV71-I-59	5/31/71	32°31.8′	117°58.7′	765	2124	10.43
S2-2	5/08/75	32°50.4′	117°47.9′	550	1635	4.18	MV67-II-16	6/12/67	36°42.8′	122°03.5′	790	1947	16.43
M10-6	2/09/72	32°34.5′	117°25.4′	550	2156	9.15	MV65-III-3	9/21/65	30°52.0′	118°07.6′	790	1746	17.40
MV65-III-34	9/26/65	32°41.3′	118°39.0′	555	2221	9.90	MV65-III-38	9/27/65	32°43.0′	118°48.5′	798	0050	9.83
M9-3	12/21/71	32°26.0′	117°33.7′	555	1935	13.58	MV67-II-28	—	37°59.0′	123°34.0′	800	2007	19.75
MV71-I-58	5/31/71	32°32.8′	117°59.5′	560	2104	10.25	MV65-I-5	6/10/65	28°51.0′	115°46.7′	814	1851	15.05
MV67-II-15	6/12/67	36°43.3′	122°03.7′	560	1925	20.38	M8-7	11/02/71	32°35.0′	118°03.1′	850	2340	10.00
M8-2	11/01/71	32°26.8′	117°34.0′	561	2212	9.05	MV67-1A-9	4/22/67	30°47.2′	117°12.7′	873	1913	12.35
MV71-I-51	5/30/71	32°22.2′	118°23.7′	563	2351	11.35	MV71-I-25	5/25/71	28°23.6′	115°47.5′	875	2149	11.02
M12-2	9/28/72	32°26.5′	117°33.8′	568	0047	7.52	MV67-IA-7	4/22/67	30°53.3′	117°13.0′	890	0215	6.00
M9-4	12/21/71	32°26.5′	117°33.5′	595	1945	14.00	MV65-III-28	9/25/65	32°50.6′	118°52.0′	896	2055	14.07
M15-5	3/31/74	35°25.0′	121°42.2′	600	0554	3.27	MV67-IA-18	4/24/67	29°35.3′	117°18.1′	900	2301	14.40
M8-3	11/01/71	32°26.2′	117°33.1′	605	2231	8.90	MV65-III-29	9/25/65	32°51.2′	118°54.8′	916	2207	12.05
MV65-III-35	9/26/65	32°41.6′	118°41.0′	610	2253	11.02	M1-3	2/01/71	32°30.1′	118°11.4′	925	2142	11.05
M12-3	9/28/72	32°26.7′	117°33.6′	610	0109	6.82	M3-2	5/12/71	32°30.5′	118°11.5′	925	2130	4.13
SC74	11/17/74	32°25.8′	117°22.1′	610	1105	4.22	M5-2	7/15/71	32°30.0′	118°11.5′	925	1956	9.00
M11-2	4/07/72	32°34.1′	117°26.9′	620	1908	9.12	M8-5	11/02/71	32°30.0′	118°11.4′	930	2158	9.53
SC79	11/03/79	32°36.0′	117°28.1′	620	1055	2.00	M6-2	8/11/71	32°30.1′	118°11.7′	937	0903	8.18
SC3-74	11/23/74	32°38.2′	117°30.0′	630	1101	7.23	MV71-I-42	5/28/71	30°11.5′	116°12.5′	938	2229	10.23
M8-4	11/01/71	32°25.6′	117°32.5′	630	2255	9.92	MV65-III-21	9/25/65	32°40.3′	118°11.8′	952	0015	9.88
MV65-III-36	9/26/65	32°42.2′	118°43.8′	631	2324	10.02	M7-3	9/14/71	32°30.0′	118°11.0′	980	2351	9.02
M11-4	4/09/72	32°26.4′	117°33.6′	647	0046	6.82	MV71-I-48	5/30/71	32°12.4′	118°14.1′	998	2138	10.88
70RI-7	10/29/70	32°34.8′	117°30.0′	655	1810	9.88	MV65-III-4	9/21/65	30°50.4′	118°08.7′	1017	1842	16.55
MV71-I-17	5/23/71	29°28.9′	117°17.1′	655	2225	13.70	MV67-IA-20	4/26/67	28°08.2′	118°13.3′	1024	0117	16.30
70RI-8	10/29/70	32°35.0′	117°30.0′	656	1820	10.00	MV71-I-60	6/01/71	32°30.0′	117°57.9′	1026	2149	10.27
SC17	7/22/75	32°34.4′	117°28.5′	660	1045	3.12	MV71-I-4	5/18/71	28°52.8′	118°10.8′	1026	2147	10.82
MV71-I-4	5/28/71	30°15.5′	116°10.7′	663	2149	10.46	MV71-I-12	5/21/71	28°52.9′	118°10.9′	1039	2001	11.90
M15-3	3/27/74	32°32.7′	117°34.3′	668	0705	4.77	MV71-I-19	5/23/71	29°31.3′	117°12.0′	1050	2133	14.73
M15-1	3/26/74	32°28.8′	117°32.1′	670	1203	4.57	MV67-IA-10	4/22/67	30°47.0′	117°03.2′	1075	2022	13.53
M8-6	11/02/71	32°35.0′	118°03.1′	670	2312	9.30	MV71-I-26	5/25/71	28°25.2′	115°49.7′	1095	2214	11.08
70RI-2	10/26/70	32°25.2′	117°28.9′	680	2230	10.92	MV67-II-18	6/12/67	36°37.1′	122°09.2′	1200	2118	17.12
70RI-3	10/26/70	32°25.2′	117°28.9′	680	2250	11.50	MV67-IA-11	4/22/67	30°53.6′	117°04.0′	1208	2103	13.53
70RI-4	10/26/70	32°25.2′	117°28.9′	680	2304	15.43	MV67-II-29	6/16/67	37°58.0′	123°38.0′	1233	2039	19.68
71RI-1	1/18/71	32°27.0′	117°29.1′	680	2110	5.33	MV67-IA-16	4/24/67	29°36.6′	117°20.4′	1382	2225	13.72
M4-1	6/22/71	32°29.6′	117°28.6′	680	1832	13.70	MV65-III-6	9/21/65	30°36.3′	118°13.4′	1391	2121	16.95
M4-2	6/22/71	32°29.8′	117°28.6′	680	1832	15.70	MV67-II-30	6/16/67	37°57.4′	123°40.5′	1480	2103	20.78
M5-1	7/05/71	32°25.2′	117°29.0′	680	1058	4.03	SIO66-50	5/21/66	40°34.6′	125°51.4′	1624	1907	13.38
M6-1	8/10/71	32°24.8′	117°28.8′	680	1110	8.92							

its flesh is extremely soft and watery. This species is frequently taken together with the Pacific grenadier in bottom trawl nets and is reported to have a wide depth range of 110-1,185 fm (200-2,170 m) (Novikov, 1970). Skin color of the giant grenadier is much lighter than that of the other two species, and individuals are usually pale when caught because most of their scales are sloughed off during capture.

The abyssal grenadier (Fig. 3) is dark brown to blackish in color with scales that are much smoother than those of the Pacific grenadier, and has 10-12 pelvic finrays (in Pacific samples) (Iwamoto and Stein, 1974), compared with (mostly) 8 for the Pacific grenadier. It is considered one of the largest grenadiers, with a largest record of 87 cm or 34 inches (Iwamoto and Stein, 1974). *C. armatus* ranges to much greater depths than the other two species. Although the known depth range for the species is between 154 and 2,570 fm (282-4,700 m) (Grey, 1956) only three records came from less than 547 fm or 1,000 m (Marshall, 1973). In the eastern North Pacific they are taken in abundance between 2,000 and 4,000 m (Iwamoto and Stein, 1974). Based on morphological differences, Wilson and Waples (1984) suggested recognition of the North Pacific population as a distinct

subspecies, *C. armatus variabilis*.

This report deals primarily with aspects that pertain to the harvest and utilization of the Pacific grenadier, providing information on fishing methods, catch rates, distribution, and qualities of its flesh. Information on its biology is also included as well as data on giant grenadier and sablefish, *Anoplopoma fimbria*, which are often caught together with Pacific grenadier.

Materials and Methods

Data Sources

Fishing data provided in this report were obtained from several sources. A large part came from free-vehicle longline (hook and line) fishing conducted by Scripps Institution of Oceanography (SIO), mainly by Carl Hubbs in 1965, 1967, and 1971 and from cruises sponsored by the SIO Marine Life Research Group (MLRG) primarily during 1971 and 1972 (Table 1). Plankton samples from the surface to near bottom depths were also collected on the MLRG cruises. More recent data were gathered during two National Marine Fisheries Service (NMFS) research cruises in September and December 1985 on the NOAA research vessel *David Starr Jordan*. On these NOAA cruises, both bottom trawl and longline gear were used to catch grenadiers and other species in deep water (Tables 2, 3).

Our study area included offshore waters north of Cedros Island to Cape Mendocino but mainly near San Diego to Monterey, Calif. (Fig. 4). Fish taken south of Pt. Conception were predominantly caught on free-vehicle longlines. Longline sets included here (Tables 1, 2) were conducted at depths of 153-1,624 fm (280-2,970 m). Trawl tows are from the *Jordan* cruises in depths of 500 to 760 fm (915-1,391 m; Table 3). Maximum trawling depth was limited by the length of cable available on the *Jordan*.

Table 2.—Longline fishing conducted on R/V *David Starr Jordan*, September and December 1985.

Cruise and sta.	Date (1985)	Lat. (N)	Long. (W)	Start fishing	Fishing time
Cruise DS85-10(193)					
1	9-19	32°56.3′	118°19.2′	0551h	8.0h
2	9-19	33°13.6′	118°59.1′	2318	6.4
3	9-20	33°05.8′	119°17.3′	2328	6.8
4	9-23	35°02.6′	121°41.5′	2343	6.2
5	9-26	32°28.7′	118°48.0′	0832	5.8
Cruise DS85-121(195)					
6	12-5	34°57.8′	121°35.1′	0032	8.0
7	12-6	35°09.4′	121°48.2′	0000	8.0
8	12-6	35°42.9′	122°11.8′	2306	7.2
9	12-9	36°55.2′	122°34.7′	1105	6.8
10	12-10	36°26.9′	122°06.3′	1106	8.0
11	12-11	37°01.7′	122°54.1′	1149	8.0

Table 3.—Trawl fishing conducted on R/V *David Starr Jordan*, September and December 1985.

Cruise and sta.	Date (1985)	Lat. (N)	Long. (W)	Start fishing	Fishing time	Depth (fm)
Cruise DS85-10(193)						
1	9-20	33°14.0′	118°58.7′	1034h	1.5h	610
2	9-21	33°02.6′	119°21.7′	0812	2.5	600
3	9-22	33°50.7′	119°26.6′	0806	1.5	690
4	9-23	35°06.3′	121°38.9′	0820	2.5	675
5	9-23	35°07.6′	121°42.1′	1256	1.5	725
6	9-24	35°06.1′	121°37.9′	0856	1.5	615
7	9-24	35°10.0′	121°38.1′	1301	1.5	550
8	9-25	34°33.4′	121°08.2′	1320	1.5	500
Cruise DS85-12(195)						
9	12-5	34°53.4′	121°34.5′	1138	1.5	600
10	12-5	34°58.5′	121°35.9′	1623	1.5	650
11	12-6	35°10.7′	121°42.3′	1115	1.5	685
12	12-7	35°44.6′	122°03.8′	1008	1.5	635
13	12-7	35°53.1′	121°56.3′	1520	1.5	700
14	12-8	36°13.2′	122°13.4′	0811	1.5	570
15	12-8	36°15.3′	122°22.9′	1410	1.5	760

Hook and Line Methods: Free-Vehicle Longline

In free-vehicle sampling, the gear or instrument package is allowed to free-fall to the sampling depth untethered to the ship. The package, which includes floats, returns to the surface after expendable weights are disengaged. The principal components of a free-vehicle longline are: 1) A main line with hooks attached and sufficient flotation to maintain positive buoyancy after the weight is released; 2) a locating float outfitted with a mast bearing a prominent flag, and as needed, other aids for locating the gear such as a radio transmitter or a strobe light; and 3) a chemical, electrical, mechanical, or sonic device which separates the disposable weight from the rest of the gear to allow the longline to return to the surface (Phleger and Soutar, 1971; Shutts, 1975). Size of gear, sampling depth, required precision of release time, and monetary costs are important considerations in choice of free-vehicle equipment.

Figure 5 illustrates a free-vehicle longline used on the *Jordan* and some of the SIO cruises. Each 19 l (5-gallon) plastic carboy, used for floatation and filled with Isopar M, an industrial solvent[2], provides about 4.5 kg (10 pounds) of flotation (Shutts, 1975). Both SIO and NMFS longlines were designed to fish vertically with a weight on the bottom of the longline and floats at the top. On each longline, from 25 to 100 hooks were spaced 1 m (39 inches) apart and baited with cut squid. The bottom hook was usually situated about 1.8 m (6 feet) off the bottom. Long-shank Mustad-Best Kirby hooks, size 8/0, were used on most SIO longline sets. On a few early SIO, as well as on most NMFS longline sets, equal numbers of these hooks were used together with size 6 or 9 Mustad tuna circle hooks. As catch results of the long-shank hooks appeared to be somewhat higher, the use of tuna circle hooks was discontinued in later SIO longline sets.

Most SIO longlines and all of those used on NMFS cruises were equipped with magnesium link release devices. Magnesium undergoes electrochemical corrosion in sea water when in contact with electron acceptors such as iron or zinc (Van Dorn, 1953; Isaacs and Schick, 1960). When the magnesium link disintegrates, the weight is detached and the rest of the gear rises to the surface. Soak time of the fishing gear was varied by using magnesium rods that were machined to specific diameters or by using "off-the-shelf" magnesium welding rods of various diameters. For precise release time, an electronically timed magnetic release mechanism[3] was also used on some of the SIO longline cruises. Two of the simpler release mechanisms made with magnesium welding rods are

[2]Isopar M, a solvent with a relatively high flash point, is manufactured by Humble Oil Refining Co. Mention of trade names or commercial firms does not imply endorsement by Scripps Institution of Oceanography or the National Marine Fisheries Service, NOAA.

[3]Daniel Brown, c/o MLRG, Scripps Institution of Oceanography, La Jolla, CA 92093. Unpubl. manuscr.

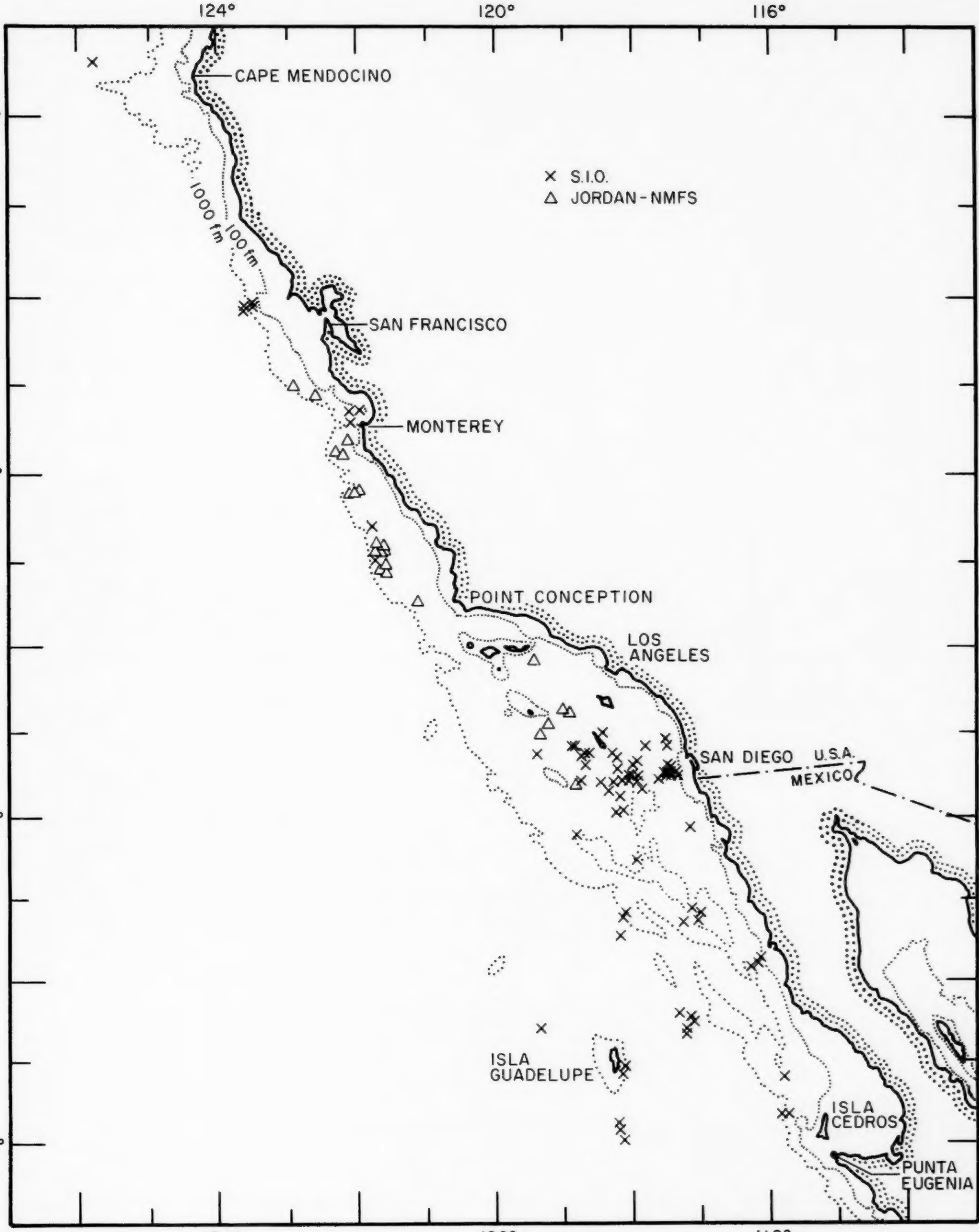

Figure 4.—Sites of fishing conducted on SIO and NMFS cruises.

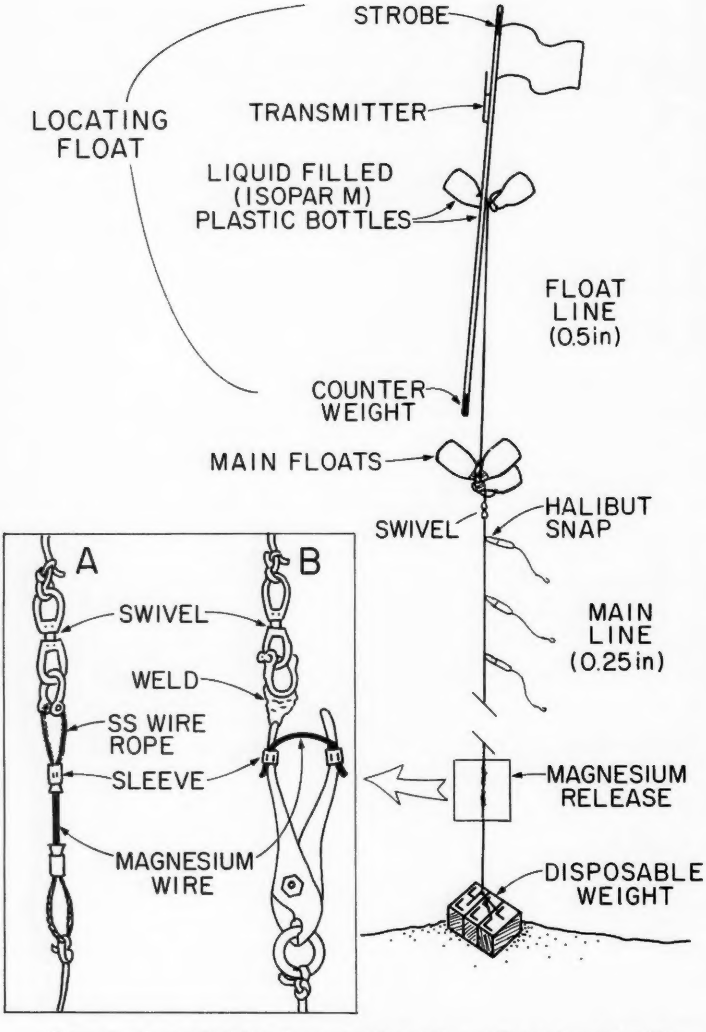

Figure 5.—Free-vehicle longline gear used to catch grenadiers in deep water. The type A release mechanism was developed by D. Brown (personal commun.) and type B by A. Soutar (Phleger and Soutar, 1974).

illustrated in the Figure 5 inset. The type shown in Figure 5A was constructed by simply crimping wire loops on a magnesium welding rod. Unlike other release devices used during SIO cruises, this type of linkage causes the magnesium rod to receive direct strain from the floats and the weight, resulting in shorter and more unpredictable release times than if no strain were present. Although unsophisticated, it gave good results on the NMFS cruises. Longlines using this device with a 2.3 mm (0.09 inch) diameter magnesium wire resurfaced after 6.1-8.2 hours in 5 trials in September 1985 and 7.6-9.0 hours in 6 trials in December 1985. On most SIO-MLRG cruises we used a modified version of the plier-release magnesium link gear described by Phleger and Souter (1971) (Fig. 5B). The strain between the weight and floats is taken up by the plier, resulting in a more predictable and consistent release time.

The research vessel was usually deployed near the setting site about 1-2 hours before the estimated time of resurfacing of the gear. The free-vehicle longline invariably resurfaced close to the drop site, but drifted away with the wind and currents at the surface. When the catch was not recovered promptly we experienced problems of predation by birds, sharks, and sea lions.

Soak time is the period of time from the disappearance below the surface of the mast when setting the longline to when the gear was again detected on the surface, through visual sighting or audible signal. We estimate that the time the gear was on the bottom, in fishing position, was about an hour less than total soak time when fishing at 500-700 fm (914-1,280 m). In a single test with a time-depth recorder, the gear took 30 minutes to sink to the bottom at 680 fm (1,244 m). Using a magnetic-release device with precise timing we obtained a rise time of 32-39 minutes from depths of 500-710 fm (915-1,299 m). The surprisingly constant rise times may have resulted from the relatively faster rise rate of the deeper sets which caught more grenadiers, which have gas bladders which expand to provide more buoyancy as the gear rises, than sablefish, which do not possess gas bladders. In shallower sets the reverse was true as more sablefish than grenadiers were caught.

Bottom Trawling

The trawl used in 1985 aboard the *David Starr Jordan* was a standard high-rise bottom trawl, designed to catch rockfish, *Sebastes* spp. The webbing was made of polypropylene twine throughout, with a stretched mesh of 114 mm (4.5 inches). The cod end had an inner liner of 12.7 mm (0.5-inch) mesh webbing. The headrope, 23 m (75 feet) long, and the footrope, 34 m (110 feet) long, were constructed of rope-wrapped wire cable and 76 mm (3 inches) rubber discs. Trawl doors were standard V-doors, 1.5 × 2.1 m (5 × 7 feet) constructed of metal frames

and wood sidings. Trawl cable diameter on the *Jordan* was 16 mm (5/8 inches), and each of two winches held 1,100 fm (2,000 m) of cable. The cable-to-depth ratio varied from 1.2:1 for deep tows, to 2:1 for shallower tows. All available cable was used for tows deeper than 650 fm (1,200 m).

All trawl tows were made in daylight hours. Tow sites were selected primarily on the basis of depth and no attempt was made to sample the study area systematically. Tow duration was 1.5 hours, starting from the time the trawl cable had been completely payed out. Towing speed was about 2 knots.

Plankton Sampling for Eggs and Larvae

Plankton was sampled during SIO-MLRG cruises using modified 1 m CalCOFI nets (Brinton, 1967), 2 m Stramin net (Wimpenny, 1966), and 3 m Isaacs-Kidd midwater trawl (IKMT) (Isaacs and Kidd, 1953). The nets were towed obliquely to sample the entire water column, with the ship underway at speeds of 1-2 knots for the CalCOFI net and IKMT, and 2-3 knots for the Stramin net. The CalCOFI nets were used in series of four nets that were opened and closed by messengers to collect discrete samples from different depths. The nets had wide collars to accommodate pursing lines to close the nets, and were towed from modified Leavitt (1938) release mechanisms. The system was essentially the same as that used by Brinton (1967). The nets, which were made with synthetic Nytex webbing with 0.3 or 0.5 mm mesh, were towed open for about an hour. Two or three series of these nets were spaced to cover the entire water column, but the coverage was uneven due to malfunction of some of the nets. Flowmeters attached to each net recorded the amount of water sampled by the net, and some of these meters were also capable of recording the depth sampled as well. A 408 kg (900 lb) lead weight was attached to the end of the cable to minimize the wire angle. These tows were taken at depths of about 400-1000 fm (732-1,829 m) on 9 cruises made in February, April, August, September, and December of 1971, February and April 1972, and March and May 1973. Open-net tows with the Stramin net and IKMT were also taken on these cruises in the same area. Stramin net tows were made on cruises of June, August, September, November, and December of 1971, and February and April 1972; and IKMT tows (in the same area but only at 600-680 fm depths) in February 1972, and March and May 1973. The Stramin net was lowered until it was near bottom, then hauled to the surface in tows that lasted 1.5-4 hours. Each IKMT station consisted of three tows using different towing wire lengths, designed to cover the entire area from near bottom to the surface. Each tow lasted 2-3 hours. The net used on the IKMT was entirely of 0.5 mm mesh Nytex netting. The Stramin net was made of 1 mm mesh Stramin netting. An acoustical pinging device monitored the approximate depth of the nets, and a Benthos time-depth recorder (model 1170) was attached to the net frame or near the distal end of the cable to record depth and time data for all plankton tows.

Data Collection and Analysis

All Pacific grenadiers caught on hook and line, and subsamples of those caught in trawls were measured, and some were weighed and sexed as well. Length measurements taken were: 1) Total length (TL; snout to tip of intact tail); 2) anal length (SVL; snout to vent); and 3) head length (HL; snout to posterior edge of gillcover). The tips of the tail of many individuals showed evidence of undergoing regenerative growth after having been severed, or were missing owing to injury during capture. These fish were excluded from length statistics reported in this paper.

Sacular otoliths were obtained from Pacific grenadier for age determination. To better differentiate the calcified bands, the otoliths were studied by the "break and burn" method (Chilton and Beamish, 1982), being split and exposed to a flame before being examined with the aid of a microscope. A FISHPARM subroutine (Saila et al., 1988) was used to generate a growth curve from estimated ages (otolith band counts) and anal lengths of 60 *C. acrolepis* of both sexes. We combined these data because of the small sample size and because of the lack of age-at-length data by sex. The subroutine fits the von Bertalanffy (1938) equation:

$$l_t = L_\infty \{1 - \exp(-K[t - t_o])\}$$

where l_t is anal length at time t, L_∞ is the asymptotic length, K is the growth coefficient, and t_o is the time when length would theoretically be zero.

Gonads were removed and preserved in 10 percent Formalin, and sexes were recorded for most fish caught on MLRG-SIO cruises. The material was examined later in the laboratory, and all female fish were classified as to state of maturity (immature, ripening, or spent). Ovaries collected from 28 fish caught during February, March, April, November, and December 1974 were examined to get egg counts during different stages of development. Subsamples weighing between 0.003 and 0.035 g each were taken from the anterior and posterior parts of each ovary. The ovarian tissue was treated with several drops of methylene blue solution, then flushed with water. Eggs were counted and measured and classified into the following groups:

Stage 0: Eggs nearly completely stained and measuring 0.05-0.20 mm diameter.

Stage 1: Eggs only stained on the outer half and measuring 0.20-0.28 mm.

Stage 2: Eggs unstained or only lightly stained on the outer surface and measuring 0.28-0.80 mm.

Stage 3: Eggs unstained or only lightly stained on the outer surface and measuring 0.80-1.6 mm.

Our stages 2 and 3 correspond to those used by Stein and Pearcy (1982). We found no ripe eggs that they classified as stage 4. The outer membrane of the ovaries was removed and excluded from the weight of the ovaries in our calculations.

The relationship of various body measurements to total length was calculated to allow comparison with the work of others because the long, slender, and fragile tail of *C. acrolepis* was often damaged. The relationships of anal length to weight and total length to weight

Table 4.—Catch data (listed by depth) from SIO free-vehicle longline stations recorded in Table 1. Total catch includes fish other than Pacific grenadier and sablefish.

Cruise and station	Depth (fm)	No. of hooks	Pacific grenadier		Sablefish		Total catch per hook
			Catch	No./hook	Catch	No./hook	
MV71-I-49	153	25	0	0	13	0.52	0.64
MV71-2	240	25	0	0	6	0.24	0.24
MV71-I-46	293	25	0	0	9	0.36	0.40
MV71-I-50	304	25	0	0	20	0.80	0.80
MV71-I-57	310	25	0	0	15	0.60	0.60
MV71-I-40	320	25	0	0	7	0.28	0.28
MV71-2	330	25	0	0	11	0.44	0.44
MV65-III-18	337	30	0	0	6	0.20	0.20
MV71-I-52	346	25	0	0	17	0.68	0.68
M6-3	400	50	0	0	23	0.46	0.46
MV67-II-26	400	30	0	0	25	0.83	0.83
SC2-74	420	100	0	0	35	0.35	0.35
MV65-II-33	426	30	0	0	10	0.33	0.33
M1-2	445	100	0	0	32	0.32	0.32
M5-3	445	50	0	0	14	0.28	0.28
M3-3	445	100	0	0	23	0.23	0.23
MV71-I-24	453	26	0	0	10	0.38	0.38
MV67-IA-22	455	30	0	0	0	0	0.03
MV71-I-16	490	26	3	0.12	0	0	0.12
M10-5	530	50	1	0.02	30	0.60	0.62
MV67-IA-28	536	30	4	0.13	0	0	0.17
MV65-III-24	537	30	2	0.07	10	0.33	0.40
S2-2	550	100	2	0.02	10	0.10	0.12
M10-6	550	50	5	0.10	17	0.34	0.44
MV65-III-34	555	30	1	0.03	18	0.60	0.63
M9-3	555	50	7	0.14	19	0.38	0.54
MV71-I-58	560	25	9	0.36	8	0.32	0.68
MV67-II-15	560	30	12	0.40	9	0.30	0.70
M8-2	561	50	12	0.24	13	0.26	0.50
MV71-I-51	563	25	12	0.48	2	0.08	0.56
M12-2	568	50	15	0.30	18	0.36	0.66
M9-4	595	50	5	0.10	12	0.24	0.34
M15-5	600	69	13	0.19	8	0.12	0.30
M8-3	605	50	15	0.30	11	0.22	0.52
MV65-III-35	610	30	6	0.20	5	0.17	0.37
M12-3	610	50	19	0.38	20	0.40	0.78
SC74	610	100	43	0.43	6	0.06	0.49
M11-2	620	50	11	0.22	10	0.20	0.44
SC79	620	50	6	0.12	1	0.02	0.14
SC3-74	630	50	15	0.30	16	0.32	0.62
M8-4	630	50	10	0.20	19	0.38	0.58
MV65-III-36	631	30	3	0.10	15	0.50	0.60
M11-4	647	93	7	0.08	3	0.03	0.11
70RI-7	655	25	11	0.44	6	0.24	0.68
MV71-I-17	655	26	13	0.50	0	0	0.50
70RI-8	656	25	7	0.28	5	0.20	0.48
SC17	660	99	5	0.05	0	0	0.05
MV71-I-4	663	25	8	0.32	3	0.12	0.44
M15-3	668	100	21	0.21	7	0.07	0.28
M15-1	670	100	22	0.22	4	0.04	0.26
M8-6	670	50	21	0.42	1	0.02	0.44
70RI-2	680	25	11	0.44	5	0.20	0.64
70RI-3	680	25	11	0.44	5	0.20	0.64
70RI-4	680	25	6	0.24	0	0	0.28
71RI-1	680	100	40	0.40	24	0.24	0.64
M4-1	680	100	54	0.54	8	0.08	0.62
M4-2	680	50	30	0.60	4	0.08	0.68
M5-1	680	100	14	0.14	1	0.01	0.15
M6-1	680	57	26	0.46	13	0.23	0.68
M7-1	680	50	19	0.38	9	0.18	0.56
M9-1	680	50	15	0.30	11	0.22	0.52
M9-2	680	50	19	0.38	13	0.26	0.64
M10-2	680	50	22	0.44	14	0.28	0.72
M10-4	680	50	7	0.14	15	0.30	0.44
M11-3	680	49	16	0.33	4	0.08	0.41
M12-1	680	100	36	0.36	18	0.18	0.54
M13-1	680	200	53	0.26	22	0.11	0.38
MV67-IA-3	690	30	17	0.57	4	0.13	0.70
SC75	700	50	14	0.28	1	0.02	0.30
MV71-I-47	702	25	11	0.44	2	0.08	0.52
MV71-I-11	710	40	12	0.30	0	0	0.30
S2-1-1	710	100	17	0.17	1	0.01	0.19
MV65-III-37	712	30	12	0.40	4	0.13	0.57
MV71-I-10	715	40	14	0.35	0	0	0.42
M2A1	730	100	54	0.54	2	0.02	0.56
M2A2	730	50	33	0.66	1	0.02	0.68
71RI-2	735	50	4	0.08	4	.08	0.20
MV65-III-19	738	30	11	0.37	0	0	0.40
MV65-III-26	748	30	10	0.33	5	0.17	0.57
MV71-I-3	750	41	18	0.44	0	0	0.56
MV71-I-59	765	25	18	0.72	0	0	0.72
MV67-III-16	790	30	17	0.57	1	0.03	0.60
MV65-III-3	790	30	3	0.10	0	0	0.10
MV65-III-38	798	30	8	0.27	1	0.03	0.33
MV67-II-28	800	30	9	0.30	1	0.03	0.40
MV65-I-5	814	100	18	0.18	0	0	0.19
M8-7	850	50	27	0.54	1	0.02	0.62
MV67-1A-9	873	30	17	0.57	0	0	0.57
MV71-I-25	875	26	14	0.54	1	0.04	0.62
MV67-IA-7	890	30	9	0.30	0	0	0.30
MV65-III-28	896	30	7	0.23	2	0.07	0.30
MV67-IA-18	900	30	9	0.30	0	0	0.30
MV65-III-29	916	30	6	0.20	7	0.23	0.43
M1-3	925	100	54	0.54	0	0	0.54
M3-2	925	100	15	0.15	0	0	0.15
M5-2	925	50	26	0.52	0	0	0.52
M8-5	930	50	27	0.54	0	0	0.54
M6-2	937	50	27	0.54	0	0	0.54
MV71-I-42	938	25	14	0.56	0	0	0.56
MV65-III-21	952	30	10	0.33	0	0	0.40
M7-3	980	50	37	0.74	0	0	0.74
MV71-I-48	998	25	11	0.44	0	0	0.44
MV65-III-4	1017	30	3	0.10	0	0	0.18
MV67-IA-20	1024	30	0	0	0	0	0
MV71-I-60	1026	25	14	0.31	0	0	0.38
MV71-I-4	1026	39	4	0.10	0	0	0.18
MV71-I-12	1039	39	7	0.18	0	0	0.36
MV71-I-19	1050	25	10	0.40	0	0	0.44
MV67-IA-10	1075	30	8	0.27	0	0	0.37
MV71-I-26	1095	26	8	0.31	0	0	0.38
MV67-II-18	1200	30	3	0.10	0	0	0.10
MV67-IA-11	1208	30	11	0.36	0	0	0.43
MV67-II-29	1233	30	5	0.17	0	0	0.20
MV67-IA-16	1382	30	0	0	0	0	0
MV65-III-6	1391	30	0	0	0	0	0.03
MV67-II-30	1480	30	2	0.07	0	0	0.07
SIO66-50	1624	30	1	0.03	0	0	0.10

were computed using the allometric growth equation subroutine of FISHPARM (Saila et al., 1988), which fits the equation:

$$W = aL^b$$

where W is weight (kg) and L is total or anal length (mm), and a and b are constants. The relationship of anal length to total length was determined by using a least square fit of the single linear equation:

$$Y = bx + a$$

where Y is total length and x is anal length.

To investigate the market potential of grenadier flesh, samples of fillet kept on ice were sent to the Utilization Research Division (URD) of the NMFS Northwest Fisheries Science Center (NWFSC), Seattle, Wash., for chemical and taste tests. A "sensory analysis panel" composed of trained URD personnel conducted tests to classify general characteristics of the cooked flesh of both Pacific and giant grenadiers.

Fishing Results

Free-vehicle Longline

Vertically set longline gear deployed

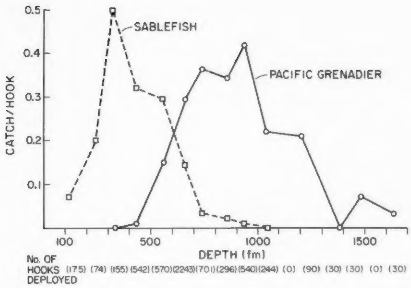

Figure 6.—SIO catch records of sablefish and Pacific grenadier by 117 free-vehicle longlines, 1965-79. Plotted points represent mean values at 100-fm depth intervals, with the number of deployed hooks representing each point in parentheses.

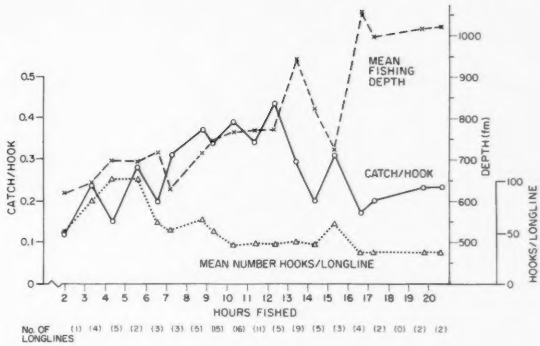

Figure 7.—Relationship of hours fished to average catch per hook, depth of fishing, and hooks per set. Data are from 97 SIO free-vehicle longlines from stations over 500 fm depth. Number of longlines are in parenthesis.

Table 5.—Catch data from longline fishing conducted on R/V *David Starr Jordan*, September and December 1985.

Cruise and station	Depth (fm)	No. of hooks	Pacific grenadier Total catch	Pacific grenadier Per hook	Sablefish Total catch	Sablefish Per hook	Total catch per hook
Cruise DS 85-10(193)							
1	695	48	0	0	1	0.02	0.02
2	626	48	5	0.10	5	0.10	0.21
3	888	48	3	0.06	3	0.06	0.12
4	835	47	12	0.26	0	0.0	0.26
5	725	48	25	0.52	0	0.0	0.52
Cruise DS 85-12(195)							
6	611	49	19	0.39	4	0.08	0.47
7	903	47	11	0.23	0	0.0	0.23
8	994	48	1	0.02	0	0.0	0.02
9	784	46	15	0.33	1	0.02	0.35
10	490	46	0	0	6	0.13	0.13
11	805	43	19	0.44	4	0.09	0.53
Total		518	110	0.21	24	0.05	0.26

at depths of 100-1,600 fm (183-2,926 m) in the sampling area (Fig. 4) caught mostly two species, Pacific grenadier and sablefish. Other species, which together made up less than 5 percent of the catch, were giant grenadier, abyssal grenadier, California slickhead, *Alepocephalus tenebrosus*, and finescale codling, *Antimora microlepis*. Longlines rarely failed to catch either sablefish or Pacific grenadier at these depths, confirming the ubiquitousness of these species over these waters.

Table 6.—Comparison of catch of Pacific grenadier on 25-, 50-, and 100-hook longlines listed in Table 4 from depths >500 fm. Actual number of hooks of the 25-hook group varied more than the others and averaged 28.4 hooks per longline.

Item	25-hook	50-hook	100-hook	Total
No. of longlines	47	35	15	97
No. of hooks deployed	1,328	1,724	1,492	4,544
Total catch	394	559	402	1,355
Hours fished	608.21	341.79	106.38	1,056.38
Avg. hours fished	12.94	9.76	7.09	10.89
Avg. catch per hook	0.297	0.324	0.269	0.298
Avg. catch per hour	0.648	1.64	3.78	1.28

Catch data from 117 free-vehicle longline sets made on SIO cruises are shown in Table 4. Longline catches made on the *Jordan* are given in Table 5. Listed are catches of Pacific grenadier and sablefish, whose depth distributions overlap considerably. Sablefish were taken from 153 to 916 fm (280-1,675 m) and Pacific grenadier from 490 to 1,624 fm (897-2,972 m). Sablefish dominated the catches from 200 to 600 fm (366-1,098 m), while Pacific grenadier was most abundant at the deeper stations, especially between 600 and 1000 fm (1,098 and 1,830 m) (Fig. 6, Table 4).

Depth readings given above refer to depths to the sea floor, but both Pacific grenadier and sablefish were caught along the entire length of the vertical longline, from the lowest to the highest hooks (about 55 fm or 100 m above the sea floor). Two longline sets with baited hooks placed well off the bottom (lowest hook at 50 m or 27 fm above the bottom at station M2A2, and 25 m or 14 fm at station M4-2) produced catch rates of 0.66 and 0.30 Pacific grenadiers per hook, respectively. This shows that the fish can find bait quite high in the water column even when there is no bait near the bottom to guide the fish.

The catch rate of 97 longline sets made in depths greater than 500 fm (915 m) (Table 6) averaged 0.30 Pacific grenadiers per hook. Differences were relatively small between 25-hook (0.30 per hook average), 50-hook (0.32), and 100-hook (0.27) longlines. From these results, expectations were for hourly catch rates to increase on average nearly in proportion to the number of hooks deployed. The somewhat lower catch of 0.65 grenadiers per hour for the 25-hook sets, compared with 1.6 per hour for 50-hook sets and 3.8 per hour for 100-hook sets (Table 6), was probably due to the disproportionate number of these sets being made in depths (Table 4) near the deep end of the species' range. Averages of 97 longline catches plotted in Figure 7 show a trend of increasing fishing time and

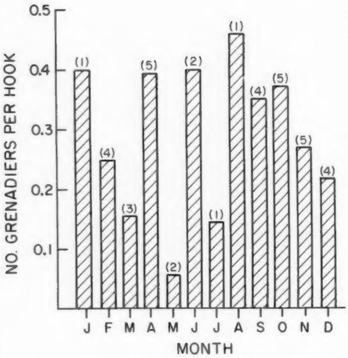

Figure 8.—Average catch rates of Pacific grenadier by free-vehicle longline, by month of fishing off southern California. Data are from SIO-MLRG fishing stations deeper than 550 fm. Number of fishing trials are in parentheses.

Table 7.—Catch (in pounds) of the most common species of fish caught per 1.5-hour tow by trawl fishing on the R/V *David Starr Jordan*. Station numbers correspond to those given in Table 3.

Station	Depth (fm)	Pacific grenadier	Giant grenadier	Sablefish	Dover sole	Channel rockfish	Total[1]
8	500	1	10	257	769	241	1,268
7	550	153	29	328	193	135	809
14	570	14	12	58	0	40	112
2	600	0	9	13	31	23	67
9	600	23	12	26	51	10	110
1	610	3	30	28	1	56	88
6	615	204	80	36	5	305	550
12	635	162	59	351	1	116	630
10	650	237	117	50	309	100	696
4	675	352	183	5	1	125	483
11	685	74	41	5	0	39	204
3	690	0	18	5	11	151	169
13	700	14	12	58	0	40	112
5	725	68	30	0	0	9	77
15	760	289	160	65	0	25	379

[1]Excluding giant grenadier, the only species presently without commercial value.

fewer hooks with increasing fishing depth. The decline in average catch per hook for longlines fished longer than 13 hours was probably also the result of fishing at deeper, less favorable depths. Catch per hook generally increased with lengths of fishing time, reaching a maximum around 8-13 hours, then declining. However, some of the highest catches were made in sets fished longer than 13 hours. For example, a catch of 0.60 fish per hook (Station M4-2 in Table 4), the second highest for Pacific grenadier, was made after 15.7 hours, and the highest catch of sablefish listed in Table 4, 0.83 per hook, (MV67-II-26) occurred when the line fished for nearly 19 hours. These results indicate that catch rates can be high with longer fishing times in productive areas. They also suggest low predation on, as well as low escapement of, hooked fish. Because sets made for longer periods were generally in very deep water, often beyond the optimum habitat of Pacific grenadier, our data probably do not reveal true catch rates after 13 hours.

Catch rates for fishing stations deeper than 500 fm (915 m) on the *Jordan* cruises (Table 5) averaged 0.21 per hook for Pacific grenadier and 0.05 for sablefish, less than the averages of 0.31 and 0.11 for the SIO cruises. The shorter average fishing time of 8.1 hours used during the *Jordan* cruises, compared with the 10.8 hours of SIO samples, may have caused the difference, but the small number of fishing stations (11) for the *Jordan* cruises also was a factor.

Figure 8, which represents the catch rate of Pacific grenadier by month, shows no clear trends in seasonal availability of Pacific grenadier off southern California. The species was available most months, though catch rates were low in several fishing trials.

Results of Trawl Fishing on R/V *David Starr Jordan*

Catches of Pacific grenadier by trawl fishing conducted on the *Jordan* are shown in Table 7. Catches of giant grenadier are included, as well as those of sablefish, Dover sole, *Microstomus pacificus*; and shortspine and longspine thornyheads, *Sebastolobus alascanus* and *S. altivelis*, respectively. The last four species are commercially valuable fishes frequently found together with Pacific grenadier. Best trawl catches of both Pacific and giant grenadiers were made in depths of 615-675 fm (1,125-1,235 m), and at the deepest trawl station, 760 fm (1,391 m). The other species were more prevalent in the shallower trawl tows, but thornyheads were also commonly caught down to 700 fm (1,281 m).

The most productive trawling locality for larger individuals of Pacific grenadier was at Santa Lucia Bank, about 50 miles northwest of Pt. Conception (Fig. 4). The area is characterized by wide expanses of flat bottom in deep water.

Plankton Sampling Results

A single 9 mm TL larval Pacific grenadier was caught in one of the CalCOFI net samples at lat. 32°31.2′N, and long. 118°05′W on 2 February 1971. The net was estimated to have sampled depths between 2.7 and 120 fm (5-220 m) from the surface over water 680 fm (1,244 m) deep. No larvae were found in the remaining 121 CalCOFI net tows made during 9 MLRG cruises, nor in twelve Stramin net samples, nor nine IKMT samples from those cruises.

Life History of the Pacific Grenadier

Distribution

Coryphaenoides acrolepis ranges from Japan and the Okhotsk and Bering Seas on the western Pacific, eastward along the Aleutian Islands to the west coast of North America (Iwamoto and Stein, 1974), as far south as Cedros Island (ca. lat. 28°N, station MV65-5, Table 1) off Baja California, Mex. It generally occurs along continental slope waters and is mainly caught with bottom sampling gear (otter trawls, bottom set hook and line). Our free-vehicle longline catches of *C. acrolepis* were made at depths ranging from 490 to 1,640 fm (896-3,000 m), the deepest capture being made at station SIO66-50. It may inhabit shallower depths at higher latitudes, as Okamura

(1970) gives a depth range for the species of 339-1,202 fm (620-2,200 m).

Table 8.—Estimated egg counts of Pacific grenadiers listed by snout to vent measurements (SVL). Cruise and station data (e.g., M15-8) is given in Table 1.

Sample	SVL (mm)	Wt. (kg)	Stage 0	Stage 1	Stage 2	Stage 3
M15-8-1	162	0.45	427,662	0	0	0
M15-1-14	189	0.75	1,188,500	59,888	1,279	20,749
M16-1-18	234	1.10	1,355,458	139,772	0	0
M13-12	238		3,193,900	357,493	3,362	0
M15-6-17	239	1.30	2,218,260	124,264	18,508	68,742
SC3-74-19	241	1.10	2,772,477	243,467	6,087	0
M16-1-9	241	1.30	3,677,071	66,274	179,270	0
M16-1-8	244	1.30	2,443,828	210,883	13,730	77,434
M16-1-16	244	1.30	3,728,688	403,977	11,932	56,676
M15-1-13	244	1.25	1,466,740	110,730	63,028	0
M15-5-21	249	1.30	1,585,946	95,966	10,042	73,090
M15-7-5	249	1.30	1,666,046	92,237	52,819	61,228
M15-1-17	262	1.60	1,246,635	225,810	90,675	0
M15-7-3	262	1.65	3,513,178	537,420	166,384	70,647
M15-1-23	262	1.60	2,503,379	174,076	87,038	0
SC3-74-22	264	1.60	2,051,348	235,664	33,921	0
M16-1-12	265	1.50	1,590,299	256,262	40,073	0
SC74-4	270	1.80	3,412,846	114,168	196,225	0
M15-6-13	276	1.75	2,364,618	246,298	42,324	60,172
SC3-74-18	276	1.70	1,668,184	163,299	8,165	0
M15-1-8	286	2.10	4,212,138	612,496	156,546	107,750
M13-3	289		3,039,594	313,322	51,509	150,258
SC74-11	296	2.00	1,079,055	103,242	9,436	102,965
M15-1-12	301	2.10	5,927,000	435,821	117,645	0
M15-3-9	304	2.10	2,564,447	468,630	231,712	0
SC3-74	315	2.50	3,882,486	385,845	10,465	111,239
M15-1-18	318	2.65	7,991,482	681,650	358,280	0

Numerous photographic observations have been made with remote cameras of Pacific grenadiers swimming near the bottom (Phleger, 1971). Although they are usually taken with bottom sampling gear, some adults (Iwamoto and Stein, 1974) as well as the youngest stages (Stein, 1980) have been caught in midwater. In Stein's samples, the youngest larvae were collected at depths less than 110 fm (200 m) from the surface, with larger larvae and juveniles occurring deeper in the water column. Savvatimskii (1969) similarly reported that small *C. acrolepis* of 10-15 mm (0.39-0.59 inch) TL were found at 55-110 fm (100-200 m) and we collected a 9 mm (0.35 inch) TL larva in a net which sampled 2.7-120 fm (5-220 m) below the surface off San Diego. These records indicate that the youngest Pacific grenadiers occur near surface layers. The largest juvenile reported taken in a midwater trawl by Stein and Pearcy (1982) measured 83 mm (3.3 inch) TL, and the smallest taken in bottom trawl, 73 mm (2.9 inches) TL. Thus the size at which the fish adopts a benthic habitat seems to be around 80 mm (3.1 inches) TL (Stein and Pearcy, 1982).

Reproduction

Ripe females of *C. acrolepis* have been reported off Kamchatka, eastern U.S.S.R., in September (Savvatimskii, 1969) and off Oregon in September, October, and April, with spent females also occurring in October (Stein and Pearcy, 1982). In the SIO-MLRG sampling program conducted off southern California, no females were found with a preponderance of ripe (2 mm) eggs. Oocytes of females with enlarged ovaries were in the ripening stage (0.8-1.6 mm). The number of females with ovaries at this stage was also relatively low throughout the year, but females with empty, flaccid ovaries that indicated a spent condition were common (Fig. 9). The number of spent females was especially high in spring and early summer. During this period the number of ripe males was also greater. However, spend females and those with ripening stage 3 (0.8-1.6 mm) oocytes were found throughout the year. Occurrence of these stages was lowest in August and September when many females carried dominant stage 2 (0.4-0.8 mm) oocytes.

Length at maturity appears to be around 650 mm (26 inches) TL for females, and about 500 mm (20 inches) TL for males. Most females with oocytes 0.8 mm and larger weighed 1.1 kg (2.4 pounds) or more and measured >650 mm (>25.6 inches) TL; the smallest was 585 mm (23 inches) TL and 0.75 kg (1.6 pounds). Stein and Pearcy (1982) found 0.8-1.6 mm eggs in individuals as small as 460 mm (18.1 inches) TL in their trawl samples. The smallest ripe male in their catches measured 485 mm (19.1 inches) TL and weighed 0.5 kg (1.1 pounds). Ripe males in our SIO-MLRG samples were always larger, but only a few individuals caught on our longlines were smaller than 500 mm (19.7 inches) TL and the smallest measured 400 mm (15.7 inches) TL.

Like other macrourids, fecundity of *C. acrolepis* is relatively high. In seven females, Stein and Pearcy (1982) estimated counts of 22,657-118,612 ($\bar{x}$ = 70,025) eggs. Our counts for 28 females are given in Table 8. Only stage 0 (0.05-0.20 mm) oocytes were present in the single immature female examined. A slightly larger female of 0.7 kg (1.6 pounds), probably just attaining maturity, had an estimated 20,749 stage 3 eggs. Highest estimated number of stage 3 oocytes was 150,258 from a female weighing around 2.0 kg (4.5 pounds).

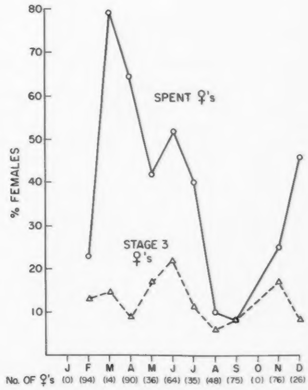

Figure 9.—Proportions of ripening and spent female Pacific grenadier making up some of the MLRG longline catches during different months of the year. Number of females are in parentheses.

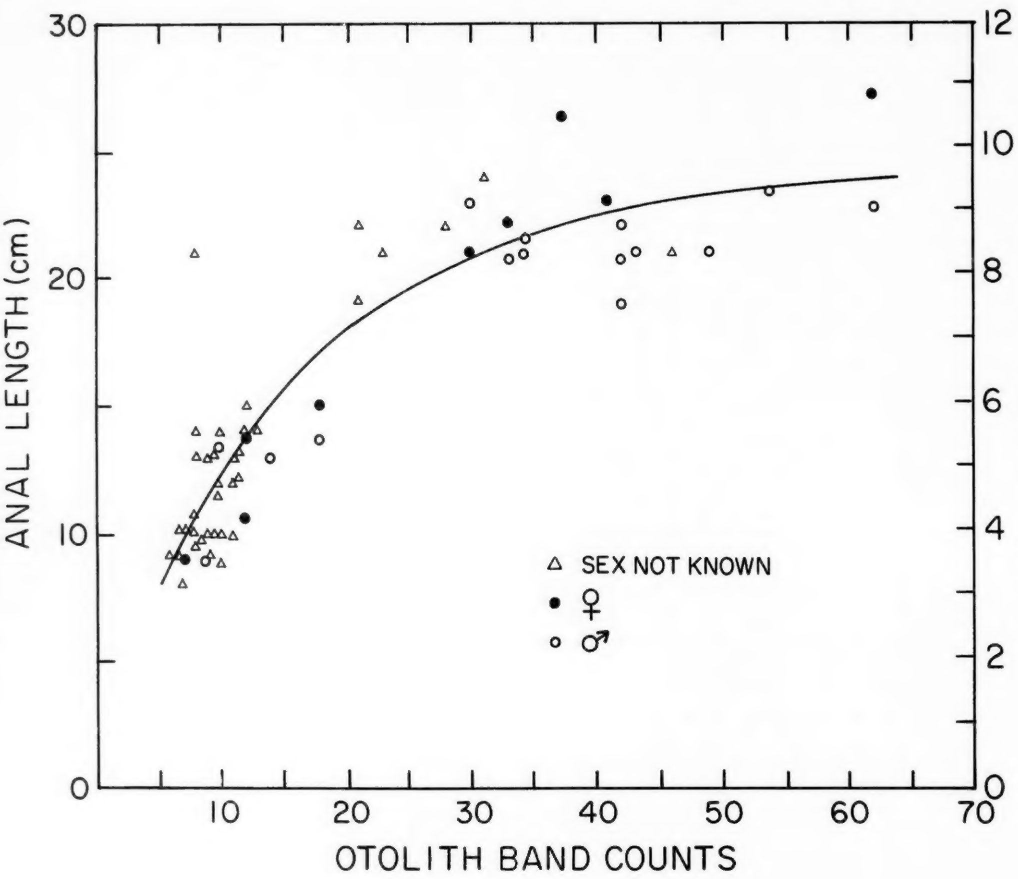

Figure 10.—A von Bertalanffy growth curve (sexes combined) and otolith ring count by size for 60 Pacific grenadiers.

The number of oocytes generally increased with fish size, but there were wide differences among individuals of similar sizes (Table 8). Stages 0 and 1 oocytes were always numerous and their numbers were independent of the developmental state of the ovaries, even in those that were spent. Nearly all oocytes found in spent females were in these stages. The presence of large numbers of stage 2 oocytes together with dominant stage 3 oocytes in some ovaries raise some questions as to the fate of the former. One can speculate a second spawning or perhaps these eggs are resorbed.

Despite the apparently high fecundity, the young of *C. acrolepis* have rarely been found. After sorting through 2,700 midwater trawls taken off Oregon, Stein (1980) found only 78 larvae and juveniles of *C. acrolepis*.

Age and Growth

Rings were found on sacular otoliths but the lines were obscure in large individuals, especially near the periphery of the otolith. We also had difficulty in reading the calcified bands in some of the otoliths from larger fish because of irregular patterns of band deposition. Even so, the data fitted the von Bertalanffy curve rather well (Fig. 10), with much of the variability about the mean explained by the least squares predictor ($R^2 = 0.82$). The growth equation for estimated ages 6-62 for both sexes was found to be represented by

$$l_t = 24.24\{1 - \exp(-0.063 [t - 1.093])\}$$

The growth curve assumes that the otolith rings represent annual growth marks, but we emphasize that we have no confirmation that this is true. Kulikova (1957, in Gordon, 1979), using rings on scales, reported a rapid growth rate for

Pacific grenadier, but Brothers et al. (1976) using sacular otoliths suggested the opposite, estimating a 58 cm (22.8-inch) individual to be 10-11 years old. As in our study, the rings were presumed to represent annual growth rings, but this has yet to be confirmed (Wilson, 1982). Our growth curve for Pacific grenadier shows a considerably slower growth rate than does Kulikova (1957), but somewhat faster than that found by Brothers et al. (1976). Known values for females in Figure 10 indicate a faster growth rate for females. Unfortunately sex records of a number of individuals are lacking, and the growth curve in Figure 10 represents all otoliths examined.

The length-weight relationships computed for 141 males and 156 females, all with intact tails (Fig. 11), were as follows:

Females

$Wt = 8.879 \times 10^{-7} AL^{2.579}$ $R^2 = 0.92$

$Wt = 6.889 \times 10^{-9} TL^{2.922}$ $R^2 = 0.90$

Males

$Wt = 5.107 \times 10^{-6} AL^{2.251}$ $R^2 = 0.81$

$Wt = 2.225 \times 10^{-8} TL^{2.725}$ $R^2 = 0.87$

where Wt is weight (kg), AL is anal length (mm), and TL is total length (mm).

The relationship of total length to anal length is given in Figure 12. A least squares fit gave the following equations:

Males

$Y = 2.308x + 122.158$

$R^2 = 0.864$ $P<0.0001$

Females

$Y = 2.276x + 115.4$

$R^2 = 0.925$ $P<0.0001$

where Y is total length and x is anal length.

Food and Feeding

Because of expansion of their gas bladders, the stomachs of grenadiers are usually everted when they are captured near the bottom and hauled to the surface. Information on food habits of *C. acrolepis*, which has a large gas bladder, is thus scarce. Pearcy and Ambler (1974) found several species of cephalopods and crustaceans and remains of amphipods and fish in a few noneverted stomachs. Okamura (1970) lists as food items squid (37 percent), euphausiids (24 percent), fish (20 percent), and prawns (19 percent). Pacific grenadier has been collected thousands of meters above the sea floor and is considered by some to be bathypelagic rather than benthic. Savvatimskii (1969) found indications that it fed on nekton and macroplankton. Several squid beaks were found by one of us in an experimental fish trap (Brown, 1975) that had caught a Pacific grenadier near the sea floor. The beaks were presumed to have been regurgitated by the fish. In the SIO stomach samples we found remains of fish, euphausiids, other crustacea, squid beaks, and in the intestines, items such as polychaetes and sponge spicules, suggesting a generalized diet which included fish, plankton, and bottom organisms. The number of intact stomach samples we were able to obtain were too few for significant analysis, however.

Flesh Characteristics

Because its tail is thin and long, the amount of flesh obtainable from Pacific grenadier is less than that from other fish of comparable size. We obtained a fillet yield (weight of flesh compared with total weight) of only 22-26 percent ($\bar{x} = 24.3$ percent) from larger individuals. Kremsdorf et al. (1979) were able to get a greater yield of 28 percent. Skin-on carcasses, with the head and intestines and most of the tail removed, averaged 50 percent of the total weight. Proximate analyses for Pacific and giant grenadiers obtained from NWFSC Utilization Research Division and other data are given in Table 9. Protein content of giant grenadier was extremely low, and that of Pacific grenadier, 15.2 percent, was also considerably lower than the average of 19.5 percent found for 35 species of fishes, excluding sharks (Gooch et al., 1987).

Findings of the sensory analysis panel at NWFSC, which tested and classified flesh characteristics of both Pacific and giant grenadier, are averaged and summarized in Table 10. Among the good attributes of Pacific grenadier flesh were firm texture, agreeable white color, and nonobjectionable taste[4]. Flesh of the giant grenadier was unpalatable, according to the panelists, primarily because of its soft texture. This was reflected in the low scores for flakiness, hardness, chewiness, and fibrousness, and high score for moistness.

Table 9.—Proximate composition (wet weight basis) for Pacific and giant grenadier.

	Pacific grenadier		Giant grenadier	
Item	Sample 1	Sample 2	Sample 1	Sample 2
Protein (%)	15.8	15.9	10.8	15.8
Fat (%)	0.1	0.2	0.2	0.2
Ash (%)	1.2	1.1	1.2	1.0
Moisture (%)	83.0	83.1	88.5	83.0
Energy (cal /100 g)	64.0	65.0	45.0	62.0
Minerals mg/g)				
Ca	148.000	111.700	180.900	175.200
Cu	0.424	0.896	0.147	0.441
Fe	3.820	4.650	3.330	3.310
K	2,748.000	3,144.000	1,368.000	3,065.000
Mg	432.000	332.000	313.000	348.000
Na	1,952.000	1,042.000	3,134.000	1,140.000
P	1,438.000	1,422.000	809.000	1,422.000
Sr	1.390	0.767	1.540	1.052
Zn	3.940	2.860	3.590	2.480

Table 10.—Characteristics of flesh and flavor profile of Pacific and giant grenadier. Scale is from 0 (none) to 7 (high). Data are from Alice Hall, NMFS, NWFSC, 2725 Montlake Blvd. E., Seattle, WA 98112.

	Pacific grenadier		Giant grenadier
Item	Sample 1	Sample 2	Sample 1
Flesh characteristics			
Darkness	1.73	0.44	0.45
Flakiness	5.09	5.44	3.36
Hardness	3.45	2.89	1.36
Chewiness	4.18	3.33	1.73
Fibrousness	4.36	3.33	2.45
Moistness	2.73	3.22	5.00
Oiliness	0.64	0.67	1.09
Flavor profile			
Flavor intensity	2.91	3.00	3.82
Sweet	1.45	2.11	0.91
Salty	2.00	1.00	3.27
Sour	0.36	0.33	0.36
Gamey	0.00	0.22	0.27
Fish oil	0.00	0.11	0.36
Shellfish	0.00	0.11	0.00
Earthy	0.53	0.51	0.30

Discussion

Until quite recently a single species of

[4]Alice Hall, Northwest Fisheries Science Center, NMFS, NOAA, 2725 Montlake Blvd. N.W., Seattle, WA 98112. Personal commun.

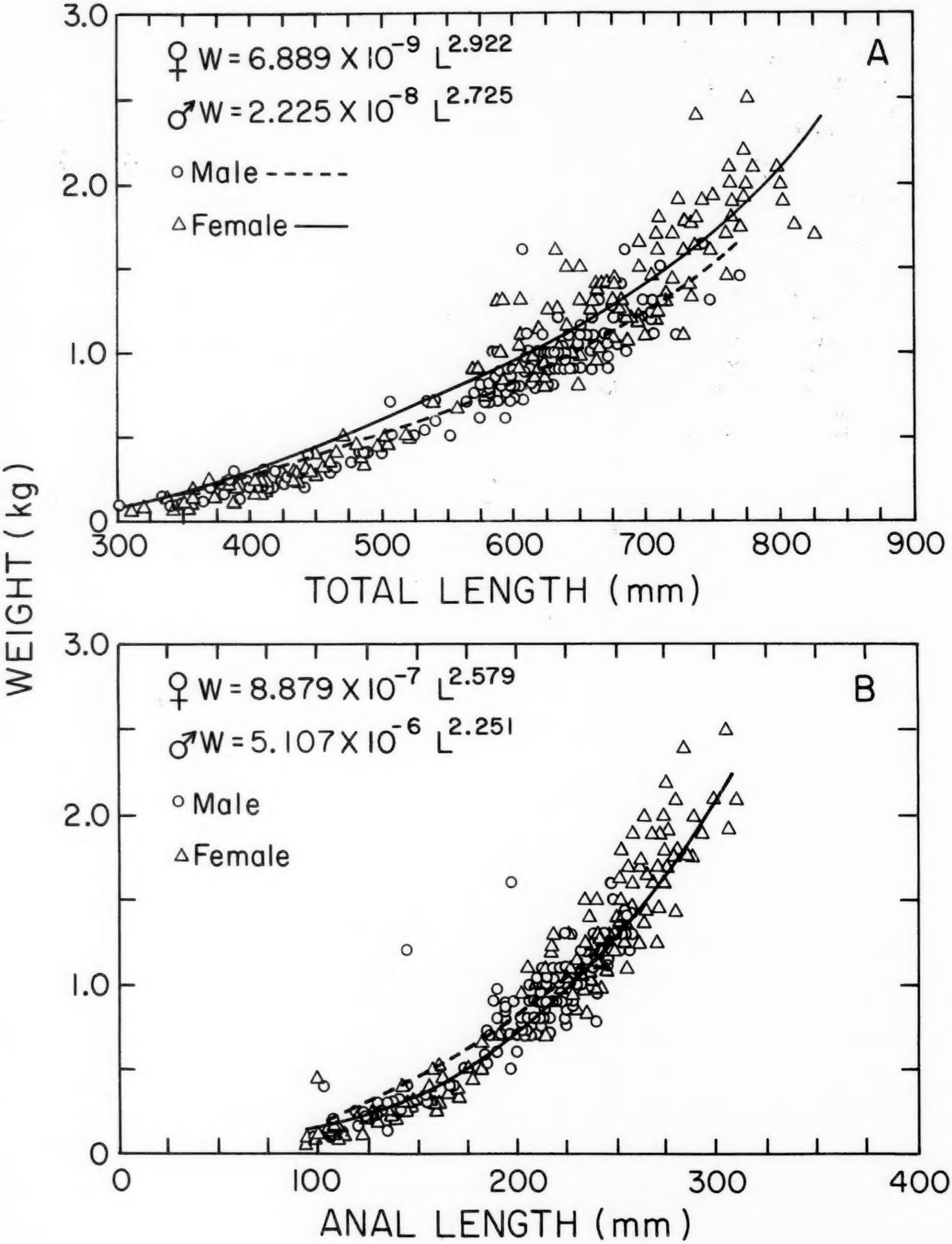

Figure 11.—Length-weight relationships of Pacific grenadier. A shows weight (kg) to total length (mm) and B illustrates weight to anal length.

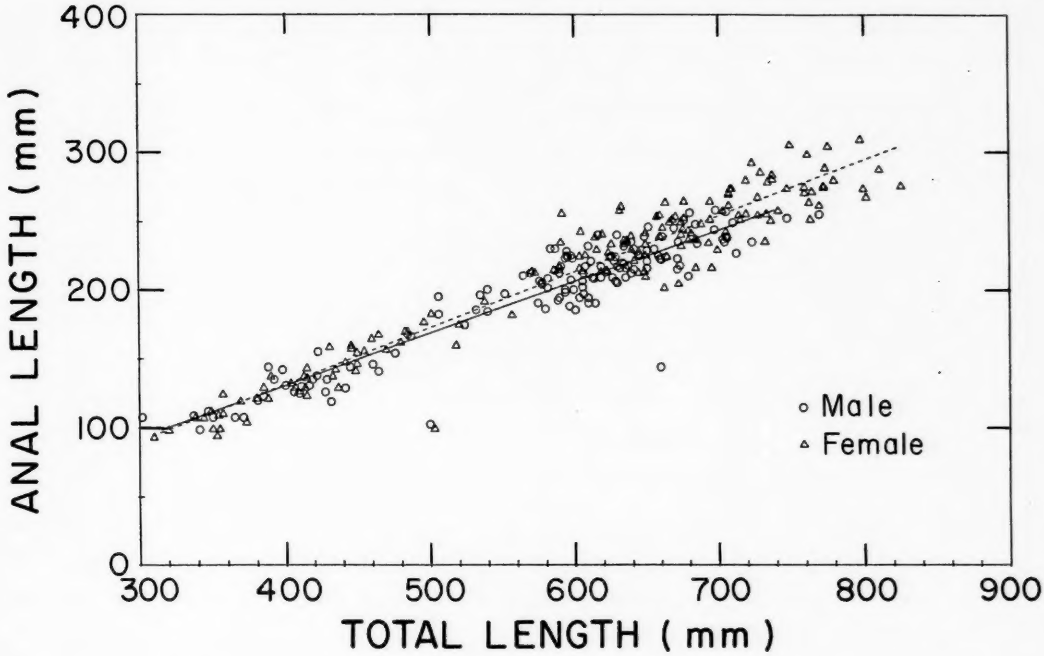

Figure 12.—Relationship of anal length to total length in the Pacific grenadier.

grenadier, *Coryphaenoides rupestris*, roundnose grenadier, made up the bulk of the world catch of the group. From 1975 to 1983 total annual catches from the northeast and northwest Atlantic, mostly by the Soviet Union, ranged from 15,000 to 65,000 t, averaging around 32,000 t (FAO, 1979, 1984). Between 1983 and 1986 however, the catches of roundnose grenadiers have averaged only 17,000 t. On the other hand catches of other species of grenadiers, again mostly by the Soviet Union, have increased rapidly. Between 1983 and 1986 the average catch of grenadiers in the southwest Atlantic (presumably *Macrourus holotrachys* and *M. carinatus*) was 18,000 t, while the catch in the northwest Pacific (presumably *Albatrossia pectoralis*, the giant grenadier) was around 17,750 t[5].

[5]Tomio Iwamoto, California Academy of Sciences, Golden Gate Park, San Francisco, CA 94118. Personal commun.

A Soviet report indicated that not only was the flesh of the roundnose grenadier good, but that its liver was also valued because of high oil and vitamin content (Savvatimskii, 1971). Novikov (1970) likewise considered the giant grenadier a valuable food species in spite of its water-logged flesh, because its liver and eggs were rich in vitamins and fats, and because of the apparently large biomass.

In Japan, grenadiers were formerly used to make a minced fish product called "surimi," which was in turn used to produce traditional jellied fish products known as "kamaboko." Pacific grenadier was satisfactory for this purpose as well as for other fish products, but giant grenadier made a poor grade of surimi (Shibata, 1985). With the advent of long-distance trawlers and factory ships, other species, particularly walleye or Alaska pollock, *Theragra chalcogramma*, have taken over this market. Most grenadiers are now caught as a bycatch in trawl fisheries aimed at other species, and the small amount landed is usually used as fish meal or fertilizer. Some species, such as *Coelorinchus tokiensis* are still sought and caught by longline, as they command good prices as food fish[6].

Canadian researchers found that the roundnose as well as another Atlantic species, the roughhead grenadier, *Macrourus berglax*, have good eating qualities and withstand iced or frozen storage better than most fish (Botta and Shaw, 1975, 1976). A similar study of the flesh of Pacific grenadier was reported by Kremsdorf et al. (1979), and their results were almost identical to those of the Canadian researchers, i.e., flesh of Pacific grenadier kept on ice for around 2 weeks did not lose its fresh quality, and taste preference tests showed that it compared favorably with Icelandic cod, *Gadus* sp. Botta and Shaw (1976) also found that 2-day old fish were easier to

[6]Osamu Okamura, Department of Biology, Kochi University, Kochi 780, Japan. Personal commun.

fillet, and yielded fillets which had better appearance and texture than fresher fish.

Sustained catches of roundnose grenadier in the Atlantic have shown that the species can support a substantial fishery. It seems unlikely, based on our fishing experience, however, that Pacific grenadier is abundant enough to warrant a directed fishery off southern and central California. Furthermore the high cost of fishing in deep water, as well as the low flesh yield and presently low price discourages development. But Pacific grenadier can be utilized when caught in deep-sea trawl fisheries directed at other species. The best depths for a mixed species trawl fishery may be around 650 fm where Dover sole, sablefish, and thornyheads are found together with Pacific grenadier (Table 6).

Longline fishing may be a viable alternative to trawls for catching Pacific grenadier because the gear is relatively inexpensive. The method is also effective for catching sablefish, which is more valuable than grenadier. Traditional vertical or horizontal longlines as well as free-vehicle longlines could be used from small vessels. Compared to free vehicle gear, traditional longline gear would require larger winches or line haulers to pull the line. Since long soak times are effective for catching Pacific grenadier, it is possible to space the setting and hauling intervals of free-vehicle longlines to maximize catches.

Further Research

The high number of ripening and spent females caught between late winter and early summer by SIO longlines indicates that this is the period of greatest spawning of Pacific grenadier off southern California. The smallest number of ripe and spent Pacific grenadier was found in late summer to fall, but presence of a few ripening and spent individuals during this period suggests that some spawning occurs throughout the year. Heaviest spawning may occur earlier farther north, as many individuals taken by trawls off Pt. Conception on the *Jordan* in December were either running ripe males or females with spent or enlarged ovaries. In even more northern waters, Savvatimskii (1969) reported ripe females only in October, and Stein and Pearcy (1982) caught ripe females in the fall and in March.

We can only speculate as to our failure to catch ripe females of Pacific grenadier with our longlines. Possibly ripe females stop feeding. It is also possible that they migrate to other areas, or higher up in the water column as has been suggested in the case of roundnose grenadier, because two females and a male of that species in spawning condition were captured about midway between the surface and sea floor over depths of 770-980 fm (1,400-1,800 m) (Grigor'ev and Serebryakov, 1983).

The youngest stages have been found 110 fm (200 m) or less from the surface (Savvatimskii, 1969; Stein, 1980), while larger larvae and juveniles have been caught deeper in the water column. The rarity of the young, considering the high fecundity of the fish, is puzzling. During the SIO-MLRG cruises, only one larva was collected. These poor results are apparently the normal expectations, as demonstrated by Stein's (1980) collection of only 78 larvae and juveniles from 2,700 midwater trawls. Further, despite these sampling efforts, eggs of *C. acrolepis*, which have an outer cover with characteristic hexagonal patterns in ripe females (Boehlert, 1984) are not known to have been collected in the plankton. Neither has a larva with a yolk sac, and there is no evidence that would indicate *C. acrolepis* being viviparous or ovoviviparous. Future studies focused on locating spawning females would certainly be a profitable area of research.

Acknowledgments

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Use of Fish Corrals in the Seine Fishery of the Virgin Islands

CECIL A. JENNINGS

Introduction

Although selected aspects of the commercial fishery in the Virgin Islands have been documented since the early 1930's (Fiedler and Jarvis, 1932; Idyll and Randall, 1959; Hess, 1961; Swingle et al. 1970; Brownell, 1971; Brownell and Rainey, 1971; Sylvester and Dammann, 1972, and Olsen et al., 1978), fish corrals and their use have not been described. This account, based on personal observations made during 1985-86, summarizes commercial fishing methods in the Virgin Islands (U.S. and British), documents the use of fish corrals, and serves as an introduction to the methodologies of this harvesting technique. Interviews of commercial fishermen about how and when fish corrals are used provided information not available from direct observation. Local common names for gear type and fish species are shown in parentheses.

Commercial Gear Type

Commercial fishermen in the Virgin Islands use a variety of fishing methods, including fish traps, beach seines, and handlines (i.e., hook and line fished without a rod). Fish traps (fish pots) constitute the primary gear; handlines and beach seines are used less frequently. Fish traps are used to harvest reef fish from areas with rock or coral bottom and associated grass flats at depths to 200 m (100 fathoms). Handlines are used primarily to harvest yellowtail snapper (yellowtail), *Ocyurus chrysurus*, during their lunar aggregations, and groupers, *Epinephelus* spp., during their spawning aggregations. Handlines are also used to harvest reef fishes, usually in conjunction with setting and recovering fish traps. Cast nets and beach seines (31-64 cm stretch mesh) of varying lengths (120-200 m) and depths (6-10 m) are used to harvest migrating schools of coastal pelagic species. Cast nets and small beach seines are used to harvest small baitfishes, including dusky anchovies (white fry), *Anchoa lyolepis*; dwarf herring (blue fry), *Jenkinsia lamprotaenia*; and false pilchard (sprat), *Harengula* spp. Larger beach seines are used to harvest migrating schools of larger, highly marketable species, such as little tunny (bonito), *Euthynnus alletteratus*; bar jack (carang), *Caranx ruber*; bigeye scad (jacks), *Selar crumenophthalmus*; and mackerels, *Scomberomorus* spp. Beach seining is usually carried out with two or more boats; one boat carries the net (netboat), and one or more boats herd the school toward shallow grass flats for encirclement. After the school has been circled, both ends of the seine are dragged onshore until the bag of the seine is in shallow water and the fish are easily removed. Fish corrals (crawls) are used in conjunction with large beach seines.

Fish Corrals

Fish corrals can be temporary or permanent. In their simplest form, they are nothing more than an enclosure made with a haul seine with both ends firmly anchored on a beach (Fig. 1). The bag of the seine remains in shallow water and serves as a pen or corral which holds the fish as long as is necessary. Corrals of this kind are temporary and are most frequently used. Permanent corrals are made of poultry wire and anchored with sticks or reinforcing steel bars (Fig. 2). They typically have gates that facilitate herding the fish into the enclosure. Permanent corrals are rare and are found only in areas that are frequented by important target species.

Corrals are used when seining crews (netmen) catch more fish than their small (<10 m) fishing vessels can carry and when the catch exceeds market demands[1]. The market demand is usually low when many seine crews make large catches (1-2 metric tons) within a few days. Corralled fish are usually moved to market within a few days. Those held longer than a few days are fed a variety of food, including fish strips and baitfish. Migrating schools of dusky anchovies and dwarf herring, when available, provide excellent forage for the corralled fish. The size of these fish allows them to be herded directly through the mesh into the corral. Successful feeding of corralled fish allows them to be kept indefinitely[1].

Fish corrals provide a cost-effective method for commercial seine fishermen in the Virgin Islands to handle large catches that would otherwise be lost. Corrals allow fishermen to exploit other

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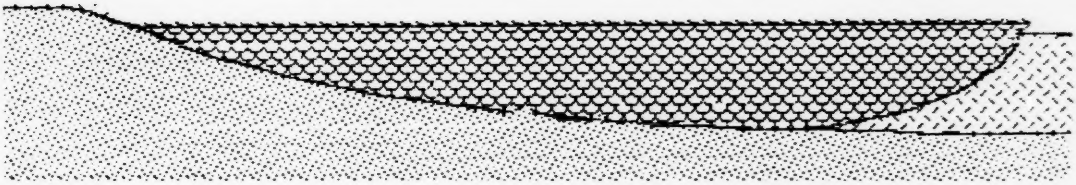

Figure 1.—A temporary fish corral with a beach seine anchored to the shore serving as the corral.

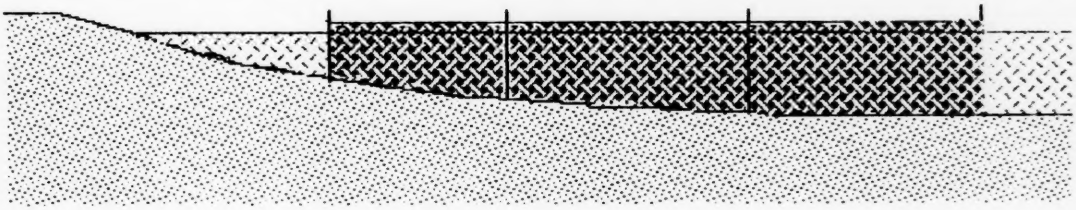

Figure 2.—A permanent corral with wire mesh supported with reinforcing steel bars (or wood) serving as the corral.

markets (i.e., at neighboring islands) when local market demands are low or to transport part of a large catch without losing the entire catch.

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U.S. Imports, Exports of Fishery Products, 1989

Imports

U.S. imports of edible fishery products in 1989 were valued at $5.5 billion, $56.2 million lower than in 1988, according to data compiled by the National Marine Fisheries Service, NOAA. The quantity of edible imports was 3.2 billion pounds, 275.2 million pounds higher than the quantity imported in 1988.

Shrimp

The quantity of shrimp imported in 1989 was 502.9 million pounds, 0.9 million pounds less than the previous record quantity imported in 1988. Valued at $1.7 billion, $49.5 million less than the 1988 value, shrimp imports accounted for 31 percent of the value of total edible imports. Imports of fresh and frozen tuna were 649.7 million pounds, 99.6 million pounds more than the 550.1 million pounds imported in 1988. Imports of canned tuna-not in oil were 347.8 million pounds, 103.6 million pounds more than the 244.2 million pounds imported in 1988.

Fillets and Steaks

Imports of fresh and frozen fillets and steaks amounted to 517.6 million pounds, a decline of 0.1 million pounds from 1988. Regular and minced block imports were 283.3 million pounds, a decline of 19.9 million pounds from 1988. Edible imports consisted of 2.6 billion pounds of fresh and frozen products valued at $4.7 billion, 532.1 million pounds of canned products valued at $639.2 million, 65.8 million pounds of cured products valued at $97.2 million, 2.1 million pounds of caviar and roe products valued at $14.4 million, and 15.6 million pounds of other products valued at $26.1 million.

Nonedible Products

Imports of nonedible fishery products were valued at a record $4.1 billion, $676.1 million more than the $3.4 billion imported in 1988. Total value of edible and nonedible products resulted in a record import value of $9.6 billion in 1989, $732.4 million more than the previous record in 1988, when $8.9 billion of fishery products were imported.

Exports

U.S. exports of edible fishery products of domestic origin were a record 1.4 billion pounds valued at a record $2.3 billion, compared with 1.1 billion pounds at $2.2 billion exported in 1988. The $111.8 million received for U.S.-flag vessel catches transferred onto foreign vessels in the U.S. Exclusive Economic Zone joint venture operations are not included in the export statistics.

Fresh and Frozen

Fresh and frozen items were 1.1 billion

TED/Tow Time Rules Go Into Effect 1 May

Regulations that require shrimp trawlers to use Turtle Excluder Devices or 90 minute tow times were scheduled to go into effect 1 May 1990, announced Dr. Andrew Kemmerer, Southeast Regional Director of the National Marine Fisheries Service. He also stressed that information and training in use of the TED's is available and urged fishermen who do not understand the rules or how to use TED's to seek help.

The requirements to begin 1 May apply to shrimp trawlers fishing in offshore waters in the South Atlantic from North Carolina through Florida and in inshore waters from North Carolina through Texas. Shrimp trawlers 25 feet or longer fishing in offshore Atlantic waters must have all nets equipped with qualified TED's. Vessels less than 25 feet can use qualified TED's or restrict tow times to 90 minutes or less. In inshore waters all shrimp trawlers regardless of size must limit tow times to 90 minutes or less or use qualified TED's. Offshore waters are distinguished from inshore waters by the 72 COLREGS line. This line is depicted by a broken purple line, or is otherwise noted on NOAA's 1:80,000 scale coastal charts. Regulations with the same requirements are already in effect in the Canaveral, southwest Florida, and Gulf offshore areas.

There are six certified TED's: The Cameron, Georgia, Matagorda, Morrison, NMFS, and Parrish. Information and technical assistance with TED's are available from several sources. Copies and summaries of the regulations, descriptions of TED's, answers to commonly asked questions and a list of TED manufacturers are available from Charles A. Oravetz, NMFS, 9450 Koger Boulevard, St. Petersburg, FL 33702; telephone 813/893-3366. General information, rule summaries, information on local manufacturers, and some technical assistance are available from local Sea Grant Marine Advisory agents. Names and numbers of marine advisory coordinators are as follows:

North Carolina	Jim Bahen	919/458-5498
South Carolina	Melvin Goodwin	803/727-2075
Georgia	Duncan Amos	912/264-7268
Florida	Marion Clarke	904/392-1837
Alabama	Bill Hosking	205/661-5004
Mississippi	Dave Burrage	601/388-4710
Louisiana	Ron Becker	504/388-6345
Texas	Mike Hightower	409/845-7526

Technical information, problem analysis, and technical assistance are available from John Watson, NMFS, 3209 Frederic Street, Pascagoula, MS 39564; telephone 601/762-4591.

pounds valued at $1.8 billion, an increase of 197.5 million pounds and $17.4 million compared with 1988. Fresh and frozen exports consisted principally of 337.4 million pounds of salmon valued at $747.3 million and 81.7 million pounds of crabs valued at $246.3 million. Canned items were 136.5 million pounds valued at $211.2 million. Salmon was the major canned item exported, with 40.4 million pounds valued at $89.7 million. Cured items were 26.7 million pounds valued at $31.6 million. Caviar and roe exports were 72.8 million pounds valued at $194.9 million, an increase of 27.9 million pounds and $50.3 million as compared to 1988.

Nonedible Products

Exports of nonedible products were valued at $2.4 billion. Exports of fishmeal amounted to 103.8 million pounds valued at $23.8 million. The total value of edible and nonedible exports was $4.7 billion. The dramatic increase of nonedible fishery products is due to the change in the new schedule B exports codes in 1989.

Table 1.—Summary of U.S. imports and exports of fishery products, 1936-89.

	Imports				Exports			
Year	Edible products		Nonedible products	Total	Edible products		Nonedible products	Total
	1,000 lb.	*$1,000*			*1,000 lb.*	*$1,000*		
1936	371,206	30,357	11,516	41,873	111,259	12,263	951	13,214
1937	364,668	33,911	16,725	50,636	119,068	13,729	838	14,567
1938	302,624	28,349	10,958	39,307	118,029	13,798	617	14,415
1939	346,240	32,404	13,595	45,999	124,974	13,580	627	14,207
1940	302,518	29,073	12,757	41,830	144,804	17,115	670	17,785
1941	305,875	28,040	12,941	40,981	215,990	21,479	529	22,008
1942	277,199	28,984	10,584	39,568	167,080	27,876	4,039	31,915
1943	324,476	43,689	23,494	67,183	239,260	43,244	5,290	48,534
1944	339,431	53,431	24,987	78,418	112,230	31,929	4,011	35,940
1945	404,768	76,434	24,820	101,254	135,979	30,855	7,655	38,510
1946	473,539	89,986	39,727	129,713	200,398	38,353	1,616	39,969
1947	407,636	83,275	26,700	109,975	207,486	49,281	3,555	52,836
1948	472,742	111,660	44,988	156,648	95,085	21,020	3,382	24,402
1949	470,517	113,753	37,861	151,614	146,660	29,212	5,838	35,050
1950	639,725	158,414	39,882	198,296	121,623	18,856	8,618	27,474
1951	646,668	158,363	54,094	212,457	164,624	27,072	8,659	35,731
1952	705,118	183,121	57,308	240,429	62,056	15,511	6,436	21,947
1953	726,195	195,869	49,611	245,480	69,308	17,084	10,794	27,878
1954	804,054	203,722	48,687	252,409	62,724	16,238	15,289	31,527
1955	780,185	208,973	49,896	258,869	109,750	24,923	15,054	39,977
1956	801,655	234,699	43,031	282,730	101,918	22,939	16,564	39,503
1957	900,227	252,788	46,487	299,275	85,221	20,549	15,403	35,952
1958	1,020,326	283,822	46,959	330,781	65,468	19,440	11,564	31,004
1959	1,141,114	314,650	55,467	370,117	80,688	26,747	17,495	44,242
1960	1,095,014	310,596	52,685	363,281	61,454	25,622	18,543	44,165
1961	1,061,662	335,757	61,301	397,058	40,137	19,594	15,116	34,710
1962	1,255,532	405,832	83,975	489,807	56,530	22,470	13,258	35,728
1963	1,196,977	399,928	100,784	500,712	64,745	30,376	26,229	56,605
1964	1,318,099	433,674	130,569	564,243	94,835	42,878	21,326	64,204
1965	1,398,778	479,412	121,492	600,904	96,444	49,308	20,175	69,483
1966	1,593,614	568,091	151,611	719,702	109,604	62,882	21,931	84,813
1967	1,470,437	538,301	169,582	707,883	107,940	67,524	14,685	82,209
1968	1,741,365	643,165	179,504	822,669	90,808	56,845	10,912	67,757
1969	1,706,571	704,809	139,484	844,293	140,646	86,474	18,059	104,533
1970	1,873,300	812,530	224,880	1,037,410	140,375	93,878	23,606	117,484
1971	1,785,470	887,070	187,131	1,074,201	171,816	113,637	25,608	139,245
1972	2,341,138	1,233,292	261,119	1,494,411	171,642	134,188	23,720	157,908
1973	2,416,193	1,398,484	184,649	1,583,133	238,942	241,866	57,302	299,168
1974	2,266,880	1,495,380	215,498	1,710,878	178,011	194,966	67,166	262,132
1975	1,913,089	1,367,180	269,919	1,637,099	218,152	267,360	37,369	304,729
1976	2,228,091	1,913,922	414,264	2,328,186	240,866	329,810	54,880	384,690
1977	2,176,189	2,078,171	555,435	2,633,606	331,059	473,375	47,121	520,496
1978	2,410,673	2,256,314	829,637	3,085,951	448,312	831,654	73,880	905,534
1979	2,358,920	2,671,860	1,136,931	3,808,791	554,294	1,022,335	62,162	1,084,497
1980	2,144,928	2,686,721	961,731	3,648,452	573,896	904,363	101,791	1,006,154
1981	2,272,474	3,034,206	1,171,805	4,206,011	669,272	1,072,765	84,230	1,156,995
1982	2,225,474	3,202,408	1,321,170	4,523,578	657,246	998,873	60,011	1,058,884
1983	2,386,771	3,626,704	1,502,668	5,129,372	601,913	907,688	113,804	1,021,492
1984	2,454,287	3,742,333	2,141,060	5,883,393	574,124	842,349	106,490	948,839
1985	2,754,018	4,064,334	2,614,252	6,678,586	648,146	1,010,268	73,846	1,084,114
1986	2,978,905	4,813,488	2,812,805	7,626,293	735,026	1,289,807	66,289	1,356,096
1987	3,201,132	[1]5,711,233	3,106,464	8,817,697	782,935	1,577,607	82,764	1,660,371
1988	2,967,786	5,441,628	3,430,369	8,871,997	1,060,186	2,155,628	118,967	2,274,595
1989	[1]3,243,017	5,497,849	[1]4,106,507	[1]9,604,356	[1]1,374,012	[1]2,282,994	[1]2,423,848	[1]4,706,842

[1]Record.

Preliminary 1989 Catch, Values of New England Fish and Shellfish Noted

Landings of fish and shellfish in New England in 1989 were down slightly from 1988, from 569.9 to 565.1 million pounds, a decrease of less than 1 percent. Value of the landings was up slightly, from $493.5 to $508.8 million in dockside or "ex-vessel" prices, an increase of 3 percent. These are preliminary figures developed by the National Marine Fisheries Service's Northeast Fisheries Center in Woods Hole, Mass. The figures are subject to minor change as late or corrected reports are received from the field.

Massachusetts again led other New England states in landings and value. The

Table 1.—Preliminary landings and values for fish and shellfish in New England States in 1988 and 1989 (rank in parentheses)[1].

	1988		1989	
State	Million pounds	Million dollars	Million pounds	Million dollars
Mass.	286.5 (1)	274.0 (1)	268.9 (1)	272.8 (1)
Maine	157.3 (2)	123.9 (2)	151.1 (2)	132.5 (2)
R.I.	106.2 (3)	69.4 (3)	125.1 (3)	75.0 (3)
N.H.	10.8 (4)	8.8 (5)	11.4 (4)	10.2 (5)
Conn.	9.1 (5)	17.4 (4)	8.6 (5)	18.3 (4)
Total	569.9	493.5	565.1	508.8

[1] Landings of lobster and crab in live weight; other shellfish in meat weight.

Table 2.—Preliminary landings and values of fish and shellfish in New England by principal port for 1988 and 1989 (rank in parentheses)[1].

Port	1988 Million pounds	1988 Million dollars	1989 Million pounds	1989 Million dollars
Gloucester, Mass.	107.4 (1)	30.8 (2)	98.6 (1)	30.0 (3)
New Bedford, Mass.	90.3 (2)	140.9 (1)	90.4 (2)	141.0 (1)
Portland, Maine	43.9 (4)	30.4 (3)	49.0 (3)	34.4 (2)
Pt. Judith, R.I.	49.6 (3)	25.4 (4)	48.3 (4)	23.6 (4)
Rockland, Maine	40.6 (5)	6.7 (8)	24.8 (5)	7.0 (8)
Provincetown/ Chatham, Mass.	25.2 (6)	11.6 (6)	23.7 (6)	12.9 (6)
Boston, Mass.	20.8 (7)	14.5 (5)	17.3 (7)	14.4 (5)
Newport, R.I.	12.8 (8)	11.6 (6)	12.3 (8)	11.5 (7)

[1] Landings of fish, lobster, and crab in live weight; other shellfish in meat weight.

Table 3.—Preliminary landings and values of fish and shellfish in New England by species for 1988 and 1989[1].

Species	1988 Million pounds	1988 Million dollars	1989 Million pounds	1989 Million dollars
Atl. herring	89.1	5.1	89.6	5.0
Atl. cod	75.4	42.3	77.6	47.2
Am. lobster	45.2	133.6	48.7	135.2
Pollock (Boston bluefish)	32.9	11.1	23.2	9.8
Silver hake (whiting)	24.9	5.3	22.6	4.3
Sea scallop	18.4	80.0	20.6	84.0
Winter flounder (blackback, lemon sole)	16.7	20.7	13.6	18.5
Yellowtail flounder	10.9	13.0	11.5	12.6
White hake (ling)	10.5	3.2	11.3	4.4
N. shrimp	6.8	7.5	8.0	7.9
Summer flounder (fluke)	7.7	11.6	5.0	9.0
Scup (porgy)	7.9	5.4	4.0	3.0
Swordfish	4.1	12.0	4.0	11.3
Haddock	6.4	7.0	3.8	4.6

[1] Landings of fish, lobster, and shrimp in live weight; scallops in meat weight.

Table 4.—Preliminary landings and values of lobster in New England by state for 1988 and 1989 (rank in parentheses)[1].

State	1988 Million pounds	1988 Million dollars	1989 Million pounds	1989 Million dollars
Maine	21.7 (1)	60.7 (1)	23.3 (1)	59.2 (1)
Mass.	15.5 (2)	47.3 (2)	16.2 (2)	48.5 (2)
R.I.	4.9 (3)	15.6 (3)	5.7 (3)	17.5 (3)
Conn.	2.0 (4)	6.8 (4)	2.1 (4)	6.4 (4)
N.H.	1.1 (5)	3.2 (5)	1.4 (5)	3.6 (5)
Total	45.2	133.6	48.7	135.2

[1] Landings in live weight.

biggest gain in landings among states was by Rhode Island, up 18.9 million pounds; biggest gain in value was by Maine, up $8.6 million. Gloucester, Mass., again led other New England ports in landings; New Bedford, Mass., again led in valuc. The biggest gains in landings and value among ports were by Portland, Maine, up 5.1 million pounds and $4.0 million.

For food fish and shellfish, respectively, Atlantic herring and American lobster again led other species in landings; Atlantic cod and lobster again led in value. The biggest gains in landings among food fish and shellfish, respectively, were by cod, up 2.2 million pounds, and lobster, up 3.5 million pounds. The biggest gains in values, respectively, were by cod, up $4.9 million, and sea scallop, up $4.0 million.

Maine again led the New England states in lobster landings and value. The biggest gain in landings was by Maine, up 1.6 million pounds; biggest gain in value was by Rhode Island, up $1.9 million. Tables 1-3 list complete landings and values by state, port, and species; Table 4 lists lobster landings and values by state.

Preliminary 1989 Catch, Value of Middle Atlantic, Chesapeake Fishes Told

Landings of fish and shellfish in the Middle Atlantic and Chesapeake states during 1989 were up moderately from 1988, from 890.7 to 949.2 million pounds, an increase of 7 percent. Value of the landings was up slightly, from $281.8 to $285.3 million in dockside or "ex-vessel" prices, an increase of 1 percent. These are preliminary figures developed by the National Marine Fisheries Service's Northeast Fisheries Center in Woods Hole, Mass. The figures are subject to minor change as late or corrected reports are received from the field.

Virginia again led other Middle Atlantic and Chesapeake states in landings and value. Virginia also had the biggest gain in landings among states, up 41.2 million pounds; New Jersey had the biggest gain in value, up $6.7 million. Cape May/

Table 1.—Preliminary landings and values of fish and shellfish from Middle Atlantic and Chesapeake States during 1988 and 1989 (rank in parentheses).

State	1988 Million pounds[1]	1988 Million dollars	1989 Million pounds[1]	1989 Million dollars
Va.	650.8[2] (1)	104.3 (1)	692.0[2] (1)	100.0 (1)
N.J.	112.7 (2)	72.1 (2)	128.5 (2)	78.8 (2)
Md.	84.3 (3)	49.5 (4)	84.9 (3)	52.1 (3)
N.Y.	37.2 (4)	52.8 (3)	36.9 (4)	50.9 (4)
Del.	5.7 (5)	3.1 (5)	6.9 (5)	3.5 (5)
Total	890.7	281.8	949.2	285.3

[1] Landings of bivalve mollusks (clams, scallops, oysters, etc.) in meat weight; Landings of fishes, crustaceans, and squids in live weight.
[2] Includes landings of menhaden, a nonfood (industrial) species.

Table 2.—Preliminary landings and values of fish and shellfish in the Middle Atlantic and Chesapeake's principal ports during 1988 and 1989 (rank in parentheses).

Port	1988 Million pounds[1]	1988 Million dollars	1989 Million pounds[1]	1989 Million dollars
Cape May/Wildwood, N.J.	47.9 (1)	28.4 (2)	54.0 (1)	30.8 (1)
Atl. City, N.J.	27.7 (2)	12.6 (4)	33.9 (2)	15.5 (3)
Ocean City, Md.	21.1 (3)	8.5 (5)	24.6 (3)	9.1 (4)
Pt. Pleasant, N.J.	17.3 (5)	6.2 (6)	19.2 (4)	8.4 (6)
Hampton Roads, Va.	20.0 (4)	34.4 (1)	15.3 (5)	17.8 (2)
Montauk, N.Y.	13.2 (6)	14.7 (3)	9.6 (6)	8.5 (5)

[1] Landings of bivalve mollusks (clams, scallops, oysters, etc.) in meat weight; landings of fishes, crustaceans, and squids in live weight.

Table 3.—Preliminary landings and values of Middle Atlantic and Chesapeake food fish and shellfish during 1988 and 1989.

Species	1988 Million pounds[1]	1988 Million dollars	1989 Million pounds[1]	1989 Million dollars
Blue crab, hard	90.2	25.7	100.5	42.0
Atl. surfclam	57.6	26.2	62.1	28.1
Ocean quahog	43.1	12.4	47.5	13.8
Squids	17.6	5.3	18.1	5.6
Silver hake (whiting)	10.3	3.1	16.7	5.0
Sea scallop	10.1	40.7	11.7	43.5
Summer flounder (fluke)	17.7	21.7	8.1	11.9
Atl. mackerel	9.6	1.0	7.3	0.8
East. oyster	5.7	16.6	4.4	15.8
Am. lobster	3.1	10.2	4.3	13.6
Scup (porgy)	4.7	3.1	3.8	3.1
Weakfish (gray sea trout)	5.3	2.5	3.8	2.7
Softshell clam	4.5	9.2	3.2	6.0
Bluefish	7.5	1.4	3.2	0.4

[1] Landings of bivalve mollusks (clams, scallops, oysters, etc.) in meat weight; landings of fishes, crustaceans, and squids in live weight.

Table 4.—Preliminary landings and values of Atlantic surfclams from Middle Atlantic and Chesapeake states during 1988 and 1989 (rank in parentheses)[1].

State	1988 Million pounds	1988 Million dollars	1989 Million pounds	1989 Million dollars
New Jersey	37.2 (1)	17.0 (1)	42.9 (1)	20.0 (1)
Virginia	10.6 (2)	4.8 (2)	7.3 (2)	3.1 (2)
New York	2.9 (4)	1.1 (4)	6.3 (3)	2.4 (3)
Maryland	6.9 (3)	3.3 (3)	5.6 (4)	2.6 (4)
Total	57.6	26.2	62.1	28.1

[1] Landings in meat weight.

Wildwood, N.J., again led other Middle Atlantic and Chesapeake ports in landings, and replaced Hampton Roads, Va., as the leader in value. The biggest gains in landings and value among ports were by Atlantic City, N.J., up 6.2 million pounds and $2.9 million.

Hard blue crabs again led other Middle Atlantic and Chesapeake seafood species in landings; sea scallops again led in value. The biggest gains in landings and values were by hard blue crabs, up 10.3 million pounds and $16.3 million. Two other major shellfish species of the Middle Atlantic-Chesapeake area, Atlantic surfclams and ocean quahogs, had gains in both landings and values. The area's leading finfish species in landings and value, respectively, were silver hake (whiting) and summer flounder (fluke). New Jersey again led the Middle Atlantic and Chesapeake states in Atlantic surfclam landings and value. It also had the biggest gains in surfclam landings and value, up 5.7 million pounds and $3.0 million. Tables 1-3 list complete landings and values by state, port, and species; Table 4 lists surfclam landings and values by state.

NOAA Enforcement Investigation Results in Fine for Company

An investigation by enforcement agents of the National Oceanic and Atmospheric Administration's (NOAA) Northeast Region, in cooperation with other Federal and state agencies, resulted in a fine of $7,500 for the Rock Hall Clam and Oyster Company, Inc. of Rock Hall, Maryland. Company president, Gilbert E. Hinefelt, entered a guilty plea in the U.S. District Court for New Hampshire. The felony information charged Rock Hall with a violation of the Lacey Act. The Lacey Act is designed to prohibit the illegal trade of fish or wildlife under false labeling.

Rock Hall had previously been placed on the state embargo list by the New Hampshire Department of Health and Human Services for shipping contaminated shellfish to New Hampshire. Any company on a state embargo list is prohibited from conducting specified commercial trade in that state. The charges stated that the Rock Hall Company had falsified labels, accounts, and records in order to continue doing business in New Hampshire despite being on that state's embargo list.

The company was placed on the New Hampshire embargo list from 9 August 1988 to 4 January 1990 for shipping shellfish contaminated with fecal coliform, a bacteria harmful to humans. From 15 November 1988 to 17 December 1988 the Rock Hall Company used the names of companies not on the state embargo list to avoid seizure and condemnation of its shellfish by New Hampshire.

Drift-gillnet Harvest of Coastal Pelagic Fishes Banned in S.E. Waters

As of 13 April 1990 drift gillnets cannot be used in the exclusive economic zone (EEZ) to fish for coastal migratory pelagic fish, according to Andrew J. Kemmerer, Director, Southeast Region, National Marine Fisheries Service (NMFS). Coastal migratory pelagic fish include king mackerel, Spanish mackerel, cero, little tunny, cobia, dolphin, and, in the Gulf of Mexico only, bluefish. These fishes may not be possessed on vessels in the EEZ, or having fished in the EEZ, with a driftnet aboard. The prohibition applies to Federal waters from the U.S./Mexico border to the Virginia/North Carolina boundary and is contained in a final rule implementing Amendment 3 to the Fishery Management Plan for Coastal Migratory Pelagic Resources of the Gulf of Mexico and South Atlantic. Amendment 3 was prepared by the South Atlantic and Gulf of Mexico Fishery Management Councils. The prohibition is based on a more conservative management approach, a new management objective to minimize waste and by-catch in the fishery, and the intent to reduce negative impacts on the traditional hook-and-line fishery.

Also included in the final rule is a prohibition on the use of purse seines and run-around gillnets for the Atlantic migratory group of king mackerel, when that resource is declared overfished, and when other authorized gear can harvest the commercial allocation. Barring an emergency, this purse seine and run-around gillnet net prohibition will not be implemented for the 1990-91 fishing year because, according to the "1990 Report of the Mackerel Stock Assessment Panel," the Atlantic group of king mackerel is not "overfished."

Hurricane Forces Move by Subsea Station Aquarius

Aquarius, the world's most sophisticated subsea research station, is to be moved from the sea floor off St. Croix, U.S. Virgin Islands, to a new site during summer 1990 by the Commerce Department's National Oceanic and Atmospheric Administration (NOAA). NOAA's Office of Oceanic and Atmospheric Research and the National Undersea Research Center at Fairleigh Dickinson University, which operate *Aquarius*, have sought recommendations from the oceanic scientific community for a new site in the Caribbean, the Florida Keys, or the Bahamas.

The decision was forced by the damage to St. Croix from Hurricane Hugo and the loss of critical support services on the island, particularly access to emergency medical care. Although *Aquarius* was not damaged by Hugo, its surface support buoy was destroyed and research station facilities ashore were badly damaged. The 81-ton, 43- by 20- by 16.5-foot *Aquarius*, which has a laboratory and

living quarters that allow teams of up to six aquanaut-scientists to live and work on the sea floor for days at a time, can be floated to the surface and towed to its new location.

Since being deployed off St. Croix in November 1987, *Aquarius* has supported nearly two dozen teams of scientists conducting a variety of marine investigations, including research into how coral reefs cleanse themselves of sediment, important for planning ecologically sound coastal development, and research into the causes of a massive die-off of coral in the Caribbean in 1987 and 1988, which may provide clues to understanding the causes and effects of global climate change.

Missions conducted from the *Aquarius* research station have included a Cornell University study of chemical and structural defenses of gorgonian soft corals, the first study of chemical variations in a single species from different habitats; a Northeastern University-led study of the effects of water movement on zooplankton feeding by corals; and a University of Georgia-led study that found new evidence of how corals react to light, directly measured the amount of carbon taken up by corals feeding on zooplankton, and discovered trends in the ways corals cleanse themselves of sediments.

David Duane, director of NOAA's National Undersea Research Program, said "the new site should be able to support marine research that increases our understanding of coastal marine ecosystem processes and contributes to NOAA's mission goals to predict global climate change and its impacts, better understand the effects of pollutants on tropical marine ecosystems, and improve our understanding of the biological productivity of the oceans."

Criteria used to select the new site included: 1) A location in the Caribbean, the Bahamas, or the Florida Keys; 2) access to a diversity of ecosystems; 3) diversity and abundance of plant and animal species; 4) ready access to supplies and laboratory facilities to support *Aquarius* and the surface science team; 5) the degree to which missions can contribute to other existing science programs at the site or in the region; 6) habitat site near shore with a nearby site for shore support facilities; and 7) access to power, telephone service, potable water, and emergency medical care.

U.S.-U.S.S.R. Fishery Negotiations Concluded

The U.S.-U.S.S.R. Intergovernmental Consultative Committee on Fisheries, which was established pursuant to the 31 May 1988, U.S.-U.S.S.R. Agreement on Mutual Fisheries Relations, held its third meeting in Washington, D.C., during 16-22 March 1990. The Committee considered a number of issues, including the proposed establishment of a new treaty on Pacific salmon, as well as conservation problems posed by highseas driftnet fishing activities and the intensive unregulated fishery for walleye pollock being conducted beyond the U.S. and Soviet 200-mile zones in the central Bering Sea. The two delegations were headed by their respective representatives on the Committee: V. K. Zilanov, Deputy Minister of the U.S.S.R. Ministry of Fisheries, and Edward E. Wolfe, Deputy Assistant Secretary for Oceans and Fisheries, U.S. Department of State.

The two sides developed a draft text of a new convention for the conservation of anadromous stocks of fish (i.e., the stocks of various Pacific salmon species and steelhead trout). The Convention would promote the conservation and rational management of valuable salmonid resources of mutual concern and prohibits the fishing for and incidental taking of salmonids on the high seas, except as specifically agreed. The Committee recommended that the two sides present the joint draft text of the proposed Convention to the Governments of Canada and Japan and request multilateral discussions at an early date. The proposed Convention reflects the view of the two sides that the harvest of Pacific salmonids on the high seas is irrational and wasteful. The terms of the proposed Convention include significant enforcement provisions designed to prevent unauthorized harvest of North Pacific anadromous species. The proposed Convention would provide for a more comprehensive conservation regime than those regimes currently in place, and would, for the first time, include all four of the major countries of origin of Pacific salmonids.

The two sides reviewed disturbing information regarding the level of unregulated fishing for walleye pollock in the central Bering Sea beyond the U.S. and U.S.S.R. 200-mile zones (the so-called "donut hole area"). U.S. and Soviet fishery scientists explained to the Committee that the Bering Sea pollock resource is declining. A major factor for this decline was attributed to the intensive level of unregulated fishing conducted primarily by distant-water fishing fleets in the area beyond the U.S. and U.S.S.R. 200-mile zones. The two sides noted that the volume of unregulated fishing has grown dramatically in recent years, approaching 1.5 million metric tons annually. If unmitigated, this fishery could pose serious consequences to the biological health of the Bering Sea pollock stocks and ecologically related species, as well as to the economic and commercial interests of the Bering Sea's only coastal states, namely the U.S. and the U.S.S.R. Based on the information submitted by the scientists, members of the Committee preliminarily explored elements and principles aimed at the possible establishment of a conservation regime for the central Bering Sea. Because of the serious nature of this issue, the two sides agreed to meet bilaterally at an early date to continue these discussions.

The two sides discussed the high-seas driftnet issue. Both sides expressed great concern over the interception of U.S.- and Soviet-origin salmon in certain driftnet fisheries and other adverse impacts on the North Pacific marine environment. The two sides considered the U.N. General Assembly Resolution on driftnet fishing and its implementation, including

agreements that have been reached to assess the impacts of the fishery on target and nontarget resources, including salmonids, marine mammals, and other marine species. They noted their intention to cooperate in gathering information on the impact of high-seas driftnet fisheries and in gaining multilateral cooperation in addressing this issue.

The two sides also reviewed the close cooperation of U.S. and U.S.S.R. enterprises in the field of fisheries and agreed that such cooperation should be facilitated to the extent possible in the future. The Committee agreed to hold its next meeting in the U.S.S.R. in 1991 at a location to be announced. Source: U.S. Department of State.

Foreign Fishery Developments

Norway's Salmon Farming Industry

Introduction

Norway dominates the world farmed salmon industry, accounting for over half the world's production of farmed Atlantic salmon. The Government of Norway in 1988 permitted fish farmers to expand the size of individual farms from 8,000 m^3 to 12,000 m^3. This action is largely responsible for the increase in production of farmed Atlantic salmon from 80,000 metric tons (t) in 1988 to an estimated 110,000 t in 1989. The increase in production placed pressure on world suppliers to reduce prices for this luxury seafood. The long-term effect of this action is likely to be severe difficulties for salmon producers and marketers in Norway and elsewhere in the world.

Norwegian salmon culture is an industry with a spectacular record of success. All sectors within the industry—smolt producers, feed manufacturers, salmon farmers, and salmon exporters—have shared in a remarkable era of growth (Table 1). This growth, however, has not been achieved without problems. The sharp Norwegian production increase in recent years—an estimated 110,000 t in 1989 compared with 80,400 t in 1988 and 47,000 t in 1987—has disrupted salmon markets throughout the world. The quantities of salmon reaching commercial size have been difficult for even the skillful Norwegian exporters to market. Combined with increasing competition from other countries, the result has been a decline in world salmon prices that threatens the profitability of the industry.

Norway's production of farmed salmon could have been even higher in 1989. Early that year, some industry representatives were predicting harvests as high as 150,000 t. However, when the rapid increase in world supplies of farmed salmon made prices decline, Norwegian salmon farmers began to scale back their production estimates. By late 1989, prices received by farmers for large Norwegian salmon had fallen to about $4.90/kg (NOK 32.50/kg)—less than half of their 1987 levels. To prevent further price erosion, farmers limited supplies of fresh salmon in 1989 by harvesting only about 110,000 t of farmed salmon—still a record level—instead of the estimated 140,000 t of salmon that were approaching market size. This self-imposed restraint on 1989 production means that Norwegian farmers carried over "inventories" of harvestable salmon, raising the possibility that additional supplies of fresh Norwegian salmon would be brought to market in early 1990.

Recognizing the continuing threat to profits in the fresh salmon market, the Norwegian salmon farming industry is taking strong action to shore up prices in the short term and to limit supplies of fresh salmon in the long term. On 4 January 1990, the the Norwegian Fish Farmers Sales Organization (NFFSO) announced plans to buy and freeze up to 40,000 t of salmon. The Organization plans to borrow US$200 million from private banks to finance the freezing plan, and will impose a levy of $0.75/kg on all exports of fresh salmon in 1990, to pay off the loan. Odd Ustad, director of the NFFSO, stated that the combination of the freezing plan and the tax on exports should keep 1990 prices of fresh salmon at about $6.30/kg (42 NOK/kg). This effort, whose direct purpose is to protect prices in the fresh salmon market, will have an important indirect result: it will significantly increase Norway's involvement in the frozen salmon market, an area in which Norway has played only a limited role in the past.

The uncertain market situation in late 1989 and early 1990—as evidenced by decisions to delay the harvest of some salmon and to freeze others—mean that forecasts of Norway's farmed salmon production in 1990 were extremely tentative. The NFFSO has asked salmon producers to reduce their feeding to an absolute minimum in 1990 to limit production and a reduction in smolt production is being sought. Though a 140,000 t

Table 1.—Norway's production and exports of farmed Atlantic salmon, 1971-88, with projections for 1989-90.

	Production			Exports		
Year	Smolts (millions)	Salmon prod. (t)	No. of farms	Quantity (t)	Value ($\times 10^6$) NOK	Value ($\times 10^6$) US$
1971	N.A.[1]	98	5	995[2]	N.A.	N.A.
1972	N.A.	146	5	1,081[1]	N.A.	N.A.
1973	N.A.	171	4	977[1]	N.A.	N.A.
1974	N.A.	601	13	1,101[1]	N.A.	N.A.
1975	N.A.	862	45	1,335[1]	N.A.	N.A.
1976	N.A.	1,431	61	1,832[1]	N.A.	N.A.
1977	N.A.	2,137	84	2,254[1]	N.A.	N.A.
1978	1.8	3,540	116	3,531	N.A.	N.A.
1979	2.1	4,142	147	4,792	217	43
1980	4.8	4,153	173	4,188	263	53
1981	6.2	8,422	215	7,829	357	62
1982	7.7	10,266	300	9,718	367	57
1983	12.8	17,000	479	15,758	644	88
1984	16.0	22,300	500	19,888	965	119
1985	18.4	28,655	600	24,492	1,422	166
1986	25.9	45,675	600	39,648	1,724	233
1987	38.2	47,420	600	41,929	2,115	314
1988	75.0	80,370	600	68,026	3,299	486
1989	62.0	110,000	650	N.A.	N.A.	N.A.
1990	72.3	140,000	N.A.	N.A.	N.A.	N.A.

[1]N.A. = Not available.
[2]Includes wild salmon.

harvest had been forecast (an even larger production capacity already exists), continuing annual increases in Norway's farmed salmon production are no longer assured. Salmon farmers are likely to make 1990 production and harvest decisions based not on the capacity of their farms, but on the demand (price level) in the world salmon market.

Aquaculture Highlights

Fish farmers in western and southern Norway are more successful in profitably raising salmon than their counterparts in northern Norway. In 1988, Norwegian aquaculture specialists estimated that 90 percent of the salmon farms in northern Norway were experiencing economic difficulties and they believe that at least 50 percent were already insolvent. Some analysts attribute the problem to the harsher climate and colder waters prevailing in the northern provinces. Others claim that northern salmon farmers lack the technical expertise necessary to operate their farms successfully. Whatever the reason, one thing is clear: Production costs in southern Norway are generally lower.

The Norwegians' great success in expanding salmon production and exports in 1988 and 1989 led to complaints from European Community (EC) salmon farmers that Norwegian salmon was being "dumped"—sold below its production cost—in EC countries. So far, EC officials have not supported their farmers' protests, but the controversy has received high-level attention: In May 1989, EC Fisheries Commissioner Manuel Marin rejected a request by Scottish constituents to establish a "protection mechanism" against the growing imports of Norwegian salmon; in July 1989, members of the Scottish and Irish salmon farmers organization kept the issue alive when they announced plans to urge the EC to introduce a "minimum price" for imported fresh salmon as part of an anti-dumping program; and in December 1989, the European Commission was considering a full investigation into the pricing of Norwegian farmed salmon in the EC market. The EC may impose import duties on Norwegian salmon.

Norwegian fish farmers have been raising rainbow trout for many years, and fish farmers have recently begun raising cod, halibut, marine catfish, European eel, Arctic char, and other species of fish and shellfish. About 400 concessions have been issued by the Government of Norway for raising cod, 62 for char, 45 for halibut, 9 for turbot, and 5 for freshwater eels. Norway was expected to produce only about 4,000 t of farmed trout in 1989 (down from 9,300 t in 1988), but cod aquaculture is growing rapidly, although the total crop figures are still small. Results from research on turbot and halibut also appear promising. Much work is needed before farming of marine catfish can begin. Eel and char production, although promising, remain in the formative stages in Norway. This switch to new species could be interpreted as a sound business practice; diversification into new areas to prevent overreliance on salmon. It could also reflect the desire to "join the bandwagon" at the start of a new era in fish culture, or it could reflect a growing concern that salmon culture may face increasing difficulties. While there is considerable interest in these alternative species, the profitability of such operations has not yet been proven.

Norwegian fish farmers have established joint-venture fish farming operations in Australia, Canada (in British Columbia and New Brunswick), Chile, Iceland, Ireland, Spain, the United Kingdom (Norsk Hydro in Scotland), and in the United States (in Maine and Washington). The Government of Norway's limitations on the issuance of new farming licenses and farm sizes led many companies and capital-rich fish farmers to shift their operations to less-regulated areas overseas. The outward migration of Norwegian experience has been at least partly responsible for the growing competition in the United Kingdom, Canada, and other countries.

There were over 600 farms operating in Norway in 1989. Norway's Minister of Fisheries, Bjarne Mork Eidem (since replaced by Sven Munkejord) announced plans to award 50 new concessions in 1989, including 10 licenses for use in the Sogn Og Fjordane Province, where there already is significant salmon farming. When the salmon industry began expanding more rapidly than anticipated, however, Fisheries Minister Eidem temporarily suspended issuing new licenses, noting that salmon farmers were concentrating on quantity, rather than quality.

The increase in allowable farm size, however, has allowed Norway's production capacity to expand even without an increase in the number of salmon farms. Based on the production capacity of 300 t of fish per farm, Norway has the capacity of producing over 180,000 t of salmon annually. Production could theoretically increase another 60 percent over the estimated 110,000 t produced in 1989. Such an increase was not expected, however.

A new herring meal plant opened in Stavanger in July 1989, as part of the effort to increase production of feed. The Norwegian Government's corn agency has already increased its imports of corn for use as an additive in fish feed.

Salmon Production

Smolt farmers produced 38 million smolts in 1987, which helped produce the 80,400 t of salmon harvested in 1988 and contributed to the record 1989 production, estimated at 110,000 t (Fig. 1). Smolt farmers increased production to 75 million smolts in 1988, which could yield as much as 140,000 t of commercial-sized salmon in 1990. The growth in the production of salmon smolts (Fig. 1) can be compared with production of farmed salmon when the smolts reach maturity 2 years later. Despite the record production of salmon smolts in 1988, the long-term market requirement in Norway is estimated at 60 million smolts. Smolt production was estimated at 62 million for 1989, and is forecast to increase to 72 million in 1990. This suggests that Norwegian production of farmed salmon could begin to stabilize at between 120,000 t and 140,000 t in 1991-92.

Norwegian farmed salmon production has increased dramatically since 1971, nearly doubling every 2 years. In 1987, production slowed because an outbreak of Hitra disease infected nearly half the country's salmon farms. In 1988, however, the pace of production recovered, and the year ended with a harvest of 80,400 t. In early 1989, Norwegian salmon farmers estimated that the year's harvest would reach 140,000 t, an increase

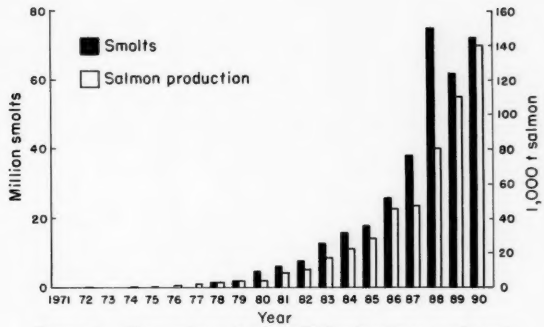

Figure 1.—Norway's production of Atlantic salmon smolts and farmed salmon, 1971-90.

of almost 80 percent over 1988 levels. During the course of 1989, however, the phenomenal growth in world supplies of farmed salmon depressed prices, threatening the viability of the huge Norwegian salmon farming industry. Salmon farmers reacted by scaling back their planned 1989 harvest considerably, to an estimated 110,000 t. This still amounted to a 25 percent increase over 1988. To better control supplies of fresh salmon, Norwegian farmers plan to freeze a significant portion of the salmon which was not harvested in late 1989.

Norway's efforts to restrain the increase of farmed salmon supplies in 1989 will affect the farmed salmon situation in 1990 in two closely related ways. First, the reduced 1989 harvest—scaled down from a forecast of 140,000 t to an estimated 110,000 t—indicates that significant quantities of market-sized salmon were carried over into 1990, increasing harvestable supplies. Second, stockpiles of frozen salmon from late 1989 and early 1990 will be available for export throughout 1990, and may affect frozen salmon prices worldwide. Even without these increased frozen supplies, Norwegian salmon farmers may be able to harvest over 140,000 t in 1990, based on the 75 million smolts produced in 1988. However, the strain on the world salmon market in 1989 indicates that Norway may again limit its production to levels below full capacity. The decreased production of smolts in 1989, compared with 1988, is further evidence that Norway will limit its production of farmed salmon during the next several years.

Salmon Farming Economics

Norwegian fish farmers need at least $600-700 million in new capital annually to finance the next season's crop. Credit problems are already starting to hurt the industry, as fish farmers struggle to obtain funds to finance increased production. Norwegian banks are increasingly reluctant to loan money, given the growing number of bankruptcies in the industry. A number of firms have declared bankruptcy because of bad management practices. Other companies invested too heavily in salmon stocks, with the result that they lacked cash for the next season. An early harvest can be very costly, because immature salmon bring little on the export market. In other instances, firms failed before they could bring their crop to market.

Setbacks have affected inexperienced salmon farmers as well as some very well established leaders in the field. In May 1989, Saga Seafoods[1], for example, filed for bankruptcy after reportedly losing $2 million. Saga Seafoods includes salmon farming pioneer Thor Mowinckel as one of the owners. Mowinckel claimed that Saga Seafoods was still in its developmental stage when it was hit by a number of mishaps and the decline in salmon prices. Being Norwegian is no guarantee of success in salmon farming, despite the reputation for success associated with the Norwegian salmon farming industry.

The Government of Norway has also examined ways to provide salmon farmers in northern Norway with direct assistance. As a result of their study, the Government decided to make $25 million in concessional loans available to salmon farmers in the north, through Norway's Central Bank. Such a program, it was hoped, would ease the industry's credit shortage and improve the profit/loss status for many of the marginal, northern producers.

Operating outlays in Norway's salmon farming sector are expected to remain high for the next 2 years. Inefficient production practices have increased freight and feed costs by millions of dollars. The decision to allow an increase in the size of salmon farms increased salmon production in 1989, presumably enhancing the economies of scale which accrue to some of the larger operations. But many costs—for example feed and electricity—are rising even for large-scale producers.

Conflicts between salmon producers in northern Norway and those located in southern and western Norway have recently surfaced. The higher production costs in the north have strained relations inside this once cohesive industry. Natural disasters, on the other hand, have been more of a threat to southern farmers. The toxic algae bloom that swept the coast of southern Norway in 1988 and 1989, serve to remind Norwegian fish farmers that they remain vulnerable to potentially costly natural threats.

The Government of Norway established size limits of 8,000 m^3 on salmon farms in the 1970s. The limited farm size (which was expected to yield 150-200 t of salmon annually) was designed to protect small farms in northern Norway where the decline in coastal wild fishing had prompted many individual fishermen to turn to salmon culture. The limited farm size was unpopular in southern Norway, however. In late 1988, the Government bowed to pressure from salmon producers in southern and western Norway and raised the size limit on salmon farms from 8,000 to 12,000 m^3. This theoretically increased the production capacity of individual farms from 200 t per year

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

to 300 t per year.

One Norwegian company, UFN A/S, however, took advantage of a temporary loophole in the regulations to establish a 282,000 m^3 production facility 10 miles off the Norwegian coast. This facility, which is said to be the largest in the world, is raising salmon for sale along the east coast of the United States. UFN A/S joins a small number of other firms that established larger fish farms before the Government first established a size limitation on salmon farms. A limited number of other firms, unable to obtain a Government-issued operating license, or frustrated with the limits on farm sizes, have invested in salmon farms overseas.

Research

Research into innovative methods for raising salmon continues in Norway. Land-based facilities are receiving the greatest attention. Under one such scheme, the salmon could be confined to small plastic bags filled with oxygen-enriched seawater pumped ashore from fjords or offshore. Because the fish would be confined to small bags, fewer wastes would be released into the environment and the transmission of illness should be reduced. Elaborate filtration systems could ensure the release of clean water back into the environment. Also, land-based farms would be protected from jellyfish, algae, parasites, seabirds, and seals. The facility could be relatively small, because oxygenation would reduce the need for water. Norsk Hydro's gas division, which developed this concept of land-based farms, is studying the system and hopes to begin marketing the concept in the near future.

While proposed land-based farms address several of the environmental problems caused by large-scale salmon culture, they are also likely to bring higher production costs. Land-based farms require more elaborate facilities than the relatively inexpensive sea-based cages, and more elaborate maintenance, such as filtration and oxygenation of water. Salmon farmers in Scotland who have moved from sea-based to land-based systems have so far reported significantly higher costs.

Development of seagoing aquaculture barges appears to be another idea that is rapidly becoming a reality. A Norwegian laboratory (Marintek) has designed an aquaculture barge for use in the open sea where rough weather prevails. The vessel would contain 12 salmon raising silos. Each silo would hold about 50 t of mature fish; this will enable the entire facility to produce 600 t of salmon annually. Designers have reduced the weight of the ship to about 450 t. The safety equipment and the anchoring system would be similar to equipment found on normal vessels. The barge would not have any propulsion machinery and would be towed to a place where it could be moored or anchored. Aqua Systems, a Norwegian company, is marketing the system and has already sold one unit to a buyer in Ireland and another to Fedje Havruk, which will anchor the barge off the island of Fedje north of Bergen. A Japanese firm is reportedly seeking to buy a third unit for offshore aquaculture in Japan. An improved version will feature fiberglass nets and undersea pontoons. Its designers believe it offers all of the advantages of a closed system at a reasonable cost.

The costs of airfreight for transporting fresh salmon to markets in Europe, North America, and Asia are universally high, because of the weight of ice used to pack the fish. Researchers at the Tromso research center recently announced a method to extend the shelf-life of fresh salmon while reducing the cost of transportation. The fresh salmon are first packed in a moist, airtight bag instead of being packed in ice. Carbon dioxide is pumped into the bag, forcing out oxygen, thus inhibiting the growth of bacteria. This extends the shelf-life of salmon from 15 to 20 days and reduces the weight of the shipment, thus saving on the cost of transportation. This new technology should begin paying dividends in 1990.

Environmental Issues

Environmentalists in Norway are complaining about the high level of antibiotics some producers administer to their fish stocks. The problem reportedly is that viruses might build up a resistance to medicine. When medicines are administered to fish in sea cages, both the medicines and the increasingly resistant viruses could spread beyond the immediate vicinity of a fish farm. The use of antibiotics increased sharply in 1988 after an outbreak of Hitra disease, *Vibrio salmonicida*, which reportedly infected nearly 50 percent of Norway's salmon farms; salmon farmers used 35 t of medicine to combat the disease. In 1989, however, the industry reduced its use of these medicines; only 4 t of antibiotics were administered during the first quarter of 1989. Better vaccines (an alternative to antibiotics) and improved smolt quality reportedly have helped farmers reduce the quantity of antibiotics used in treating their fish.

The pesticide "Nuvan," used to control sea lice, *Lepeophterius salmonis*, on salmon smolts and adult farmed salmon, is also harmful to the marine environment. As a result, Norwegian scientists are now trying wrasses—called "cleaner fish"—as a natural source for removing sea lice from salmon. Scientists at the Institute of Fishery Technology Research (FTFI), used goldsinny, rock cook, ballan wrasse, and cuckoo wrasse in cages containing salmon smolts. The results show that salmon grown in identical cages without the wrasse must be deloused with Nuvan frequently. Cages with cuckoo wrasses had to be deloused only once with Nuvan, while cages containing goldsinny and/or rock cook were 70-100 percent free from salmon lice. The wrasses also consumed the algae growing on the mesh nets, helping keep the pens clean.

Many individuals have alleged that an excessive amount of fish waste is being introduced into the environment from fish farming. However, recent research studies have revealed that less than 0.2 percent of the phosphorus and nitrogen discharged into the North Sea from Norway is generated by fish farms. The news helps the fishing industry answer public criticisms that wastes from fish farms upset the coastal ecological balance.

A new blood sickness, SAS, has recently been found at a few salmon farms. Very little is known about this disease and researchers are attempting to discover a cure for it. Biologists are concerned that concentrations of large numbers of fish in a small area will lead to outbreaks of fish diseases which could affect both wild and farmed stocks.

In June 1988, a massive algae bloom (*Chrysochromulina polylebis*) arose off the western coast of Norway and threatened several salmon farms. Although the algae growth dissipated before reaching many farms, salmon facilities had to be evacuated and some salmon was harvested prematurely. The industry lost an estimated $9 million because of the algae bloom. About two-thirds of that amount was covered by private insurance and one-third was direct losses. Oceanic conditions resulted in the return of another algae bloom during the summer of 1989, but the bloom was not nearly as disruptive as the previous one; it affected about 450-600 t of salmon worth $4 million, near Stavanger. The algae began to dissipate within a few weeks of its discovery.

Norwegian scientists are concerned about the possibility that escaping farmed salmon will spread disease or dilute the genetic pool of wild stocks. The Directorate for Nature Management has proposed a temporary moratorium on the issuance of licenses for new salmon farms.

A recent study reports that escaped cultured salmon are intermingling with wild stocks in coastal spawning grounds. A survey conducted in 1988 calculated that over 25 percent of all fish in 54 coastal watercourses were "farmed" salmon that had escaped. The number of escaping salmon reportedly doubled between 1987 and 1988.

Although researchers have not yet detected any ill effects in the wild population, due to the intermingling, they are convinced that genetic damage will occur unless protective measures are taken. Until long-term solutions are developed, however, the Directorate has recommended that a moratorium on the construction of new aquaculture sites be enacted. Representatives of Norway's salmon farming industry, however, maintain that the industry has already done much to reduce the number of escaping fish, and they dispute the estimated numbers of escaping salmon. They maintain that more land-based facilites should be built, but that a moratorium on all fish farm construction is unnecessary. In 1989, the concern over excessive supplies of farmed salmon began to overshadow this debate over limits on new salmon farms—the market dictated that production should expand more slowly.

Overseas Marketing

Many Norwegian salmon growers are beginning to worry about the future of the industry. These fish farmers stress not the technical issues involved in salmon production, but note instead the growing quantities of Norwegian salmon reaching world markets, and the declining prices. They believe that the industry has expanded too quickly and that the reputation for high quality associated with name "Norwegian salmon," will begin to erode as this superb seafood becomes a "supermarket" commodity. The anticipated increase in production of raises the danger of markets becoming glutted with salmon. Salmon prices fell 10 percent in 1988 and a rapid decrease in prices followed in 1989. Some industry analysts, on the other hand, believe that a variety of factors, such as expanding demand, will limit price declines, and that the concerns of Norwegian salmon farmers are exaggerated.

Though there is difference of opinion about the room for growth in the Norwegian salmon farming industry, there is growing consensus that the growth needs to be better controlled. Some industry spokesmen focus on export controls, advocating tougher Government regulations to ensure that the farmed salmon market continues to expand in an orderly fashion. One idea would extend the 1990 plan to impose a tax of $0.75 on each kilogram of fresh salmon exported. The revenues from the tax would finance a farmed salmon management program. Funds would be used to pay salmon farmers who did not harvest all of their crop during a given year, as a means of keeping wholesale prices stable. This recommendation, however, is controversial. Even its proponents concede that some way must be devised to make sure that the program does not violate international rules against price fixing.

Although Norway pioneered Atlantic salmon farming, the growth of salmon farming in the United Kingdom, Ireland, the Faroe Islands, Iceland, and Canada, has steadily eroded Norway's dominance. Other countries, most notably Chile and Japan, are also rapidly increasing production of Pacific salmon. Norwegian fishery officials note that Norway could easily lose further ground in the next few years because of the high cost of raising salmon in Norway. Few firms can raise salmon for under $4.00/kg; for the vast majority of producers, the costs are significantly higher. Farmed salmon sold for under $5.25/kg in 1989, which made it difficult to produce profits on a consistent basis, especially considering the strong pressure on world markets to reduce the price of salmon. Some competitors—such as Chile, with its huge fishmeal industry—have lower cost structures than does Norway.

In January 1988, a Norsk Hydro unit concluded an agreement with Skaarfisk, another Norwegian firm, establishing a new sales company specializing in farmed salmon. The new company, called Skaarfisk-Mowi, has become the largest single exporter of Norwegian farmed salmon, with an annual turnover of over $100 million, which accounts for about one-quarter of the country's total exports of farmed salmon. Most of Skaarfisk-Mowi's exports are sold to France and West Germany (75 percent), followed by the United States (15 percent), and Japan (slightly less than 10 percent).

Norway's decision to produce increasing quantities of frozen salmon—up to 40,000 t in early 1990—may have a marked affect on the world market for frozen salmon, especially in Japan. The U.S. Embassy in Tokyo reports that large-scale Norwegian exports of frozen salmon will face strong resistance in the Japanese market. Japanese buyers are apparently unwilling to accept large quantities of frozen salmon at the (early 1990) price of $5.50/kg (NOK 36/kg). Instead, Japanese buyers may press for prices in the $3.50-$4.40/kg range, since the Japanese market is already oversupplied. Norwegian wholesalers seem unlikely to reduce their prices to such a degree. Nevertheless, the potential for low-priced Norwegian imports will give Japanese buyers significant leverage when 1990 prices for U.S. frozen chum, coho, and sockeye salmon are negotiated. (Source: IFR-90/03.)

Germany's Fisheries and Fish Markets

The Federal Republic of Germany (FRG) is the world's seventh largest importer of edible fishery products. Like several other European Community (EC) nations, the FRG relies increasingly on fishery imports to supplement its declining domestic catch. Imports now account for almost 80 percent (by quantity) of edible fishery products consumed in West Germany. The value of fishery imports has increased substantially since the mid-1980's, rising from a stable level of about \$0.8 billion per year during 1980-85, to \$0.9 billion in 1986, and \$1.1 billion in 1987. Imports increased to an estimated \$1.2 billion in 1988, and should continue to expand in value and variety as German consumers become accustomed to a wider variety of fishery products.

German fisheries consumption has almost fully recovered from the setback it suffered in 1987, when televised reports about nematode parasites in fresh fish temporarily upset the market. The recovery in consumption levels has brought new trends. Quality conscious German consumers have continued to purchase large quantities of traditional species such as herring, but have also increased their purchases of higher-priced specialty fish and shellfish.

Domestic Fisheries

West Germany's domestic catch declined from 330,000 metric tons (t) in 1981 to 202,000 t in 1987, a 58 percent decrease. Loss of traditional fishing grounds, following the extensions of fishery jurisdictions, and decreasing catch quotas in European waters contributed to the steady decline. Unlike other European nations, the FRG does not have a significant fishing effort outside of the North Atlantic. During the 1980's, Germany's overall catch declined primarily because of reduced catches around Greenland and the United Kingdom (UK). EC fishing around Greenland is regulated by annual bilateral agreements. In recent years, Greenland has reserved a growing share of its resources for its own fishing fleet. Meanwhile, German quotas for cod and several other important species in EC waters have also been reduced. Catches in the North Sea, Germany's most important fishing area, have held steady but have not increased to make up for losses in other areas. As a result, the German fleet of deep-sea trawlers, factoryships, and coastal fishing vessels now supplies less than one-quarter of the fishery products consumed in West Germany.

In 1987, the value of the West German catch was about \$150 million. The largest landings were: 45,000 t of Atlantic cod, 29,000 t of haddock, 26,000 t of mussels, 17,000 t of shrimp, 16,000 t of mackerel, and 14,000 t of herring. The FRG Government has discussed expansion of the herring and mackerel fisheries, to reduce imports of these species, but EC fisheries policy currently prevents additions to the FRG fishing fleet. Thus, the FRG's domestic catch is not expected to increase significantly in the next few years.

Aquaculture

While the value of Germany's wild fisheries catch has declined in recent years, the value of its aquaculture production has steadily increased. The 9,000 fish farms in the FRG produced about 25,000 t of fish in 1988, with a value of over \$70 million—or almost half the value of the domestic catch, according to Wolfgang von Geidern, Secretary of the FRG Economics Ministry. Although the quantity of fish produced is only a small portion of the 770,000 t of fishery products consumed in West Germany, aquaculture is becoming an important source of high-value fresh and smoked fish. The FRG's growing aquaculture industry now supplies over half of the nation's consumption of trout. Lacking the superb natural sites available for salmon production in Norway, fish farmers in the FRG are instead developing high technology tank farms and sophisticated methods of raising trout. New food additives—which are somewhat controversial—allow trout to be colored so that their flesh looks like salmon.

Fish Consumption

West German consumption of fishery products, 12.6 kg per capita in 1988 (Fig. 1), is considerably lower than consumption in more coastal neighboring countries such as Denmark and the Netherlands (about 20 kg). This difference reflects regional contrasts within Germany. Consumers in northern (coastal) areas eat as much as 30 kg of fishery products per year, compared with only about 5 kg per year in southern (inland) regions.

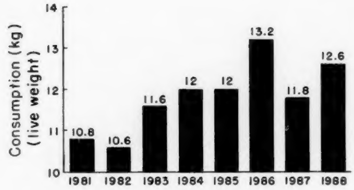

Figure 1.—FRG per capita fisheries consumption, 1981-88, live weight in kilograms.

Prices to the consumer of most fishery products are somewhat higher than prices of competing foods, thus slowing the potential growth of fisheries consumption. In 1987, average FRG retail prices were \$1.01/lb. for fresh herring, \$3.07/lb. for pollock fillets, and \$3.70/lb. for whole cod. Prices for selected nonfishery foods were \$1.30/lb. for chicken, \$2.50/lb. for beef, and \$2.78/lb. for pork cutlets.

Per capita consumption of fishery products in the FRG expanded from 10.8 kg in 1981 to 13.2 kg in 1986, a 20 percent increase (Fig. 1). During those years, Germans increased their consumption of fishery products for reasons of health and convenience. Imports replaced domestic supplies of fishery products, bringing more variety to the German market. Consumption of frozen fishery products increased particularly rapidly as these products became more diverse. As late as 1982, over half of the frozen fishery products consumed in Germany consisted merely of fish fingers. By 1986, the frozen fisheries market was 30 percent larger than in 1982 (over 90,000 t), and included a greater proportion of fish fillets, shellfish, and new convenience fishery products. The growth in consumption of both fresh and frozen fishery products led some observers to estimate that German consumption would increase to 15 kg per capita by 1988, a prediction which failed to materialize.

The increase in German fisheries con-

sumption stalled in 1987, when a parasite scare upset the market for fishery products. Environmentally conscious West Germans had increased their consumption of fishery products partly because of the healthful image of fish. The mid-1987 television and newspaper reports of parasitic worms (nematodes) found in several products—including the most popular one, marinated herring—struck a serious blow against this image. Demand for fish decreased (temporarily) by 60 percent. There was a danger that some consumer groups, especially in southern Germany, would stop buying fish altogether. Many consumers apparently linked the presence of nematodes in herring to increasing pollution in the North Sea, where most herring is caught. For these consumers, nematodes were a sign that fishery products, once symbolic of healthful nutrition, had become potentially hazardous.

The Government and the fisheries industry in the FRG reacted vigorously to the threat posed by the nematode crisis. Within weeks of the televised reports that had frightened consumers, the Government had implemented exacting regulations for the inspection and preparation of fish. With few exceptions, fish had to be eviscerated as soon as they were caught; fillets and steaks had to be individually inspected by hand using specified illumination equipment. One variety of fresh herring ("green herring") could no longer be sold whole and most fish had to be frozen at −18°C for 24 hours before being sold. (By August 1988, the Government had expanded these regulations as described below). The Government also provided close to $1 million (one-fourth of which came from EC funds) for a promotional effort to renew consumer demand for fishery products.

FRG fishery companies and marketing associations joined the effort to restore consumer confidence. The new health regulations were widely publicized, and advertising campaigns featured German celebrities enjoying fish. The Fischwirtschaftliche Marketing Institut (FIMA) distributed new recipe books and booklets such as one entitled "1,000 Facts about Fish," seeking to promote the health benefits of fish and to also spark interest in unfamiliar fishery products. Consumers responded to these measures well; by 1988 the consumption of fishery products had increased to 12.6 kg.

Government and industry efforts helped keep the nematode crisis from becoming a catastrophe but did not prevent sizable losses in the fisheries sector in 1987. Fishermen, processors, wholesalers, and retailers lost an estimated $500 million. Per capita consumption decreased from a record 13.2 kg in 1986 to 11.8 kg in 1987. Sales of herring (accounting for about one-third of the fisheries market) decreased by 25 percent compared with 1986. The setback was harsh because FIMA had forecast a comparable increase in consumption for 1987. But already during the 1987 Christmas season, when Germans traditionally eat a large amount of fish, sales of fishery products had begun to improve. The damage to the market during the "crisis year" (1987) was less severe than was originally feared.

With a few exceptions, the market for fishery products continued to recover during 1988 and 1989. Per capita consumption reached 12.6 kg in 1988, and was forecast to exceed 13.0 kg in 1989. While the market as a whole seemed to be strengthening, aftershocks of the nematode crisis showed that consumers remained cautious about fishery products. In early 1988, sales of fish in southern Germany decreased suddenly (again, temporarily) after Stuttgart newspapers reported that fish containing dead nematodes were being sold. The dead parasites posed no real health danger, but they were unappetizing reminders of the earlier crisis. Later in 1988, a Hamburg-based fisheries retailer responded to the ecologically conscious climate in the FRG when it announced that it would no longer market any fish (except plaice) originating from the North Sea. There was nothing objectively wrong with North Sea fish, company spokesmen said, but its negative image was hurting overall fishery sales. (Curiously, another company in the multinational group continued to sell North Sea fish.)

In August 1988, the FRG Government enacted detailed health regulations for fishery products sold in Germany. These regulations, which are likely to be the model for EC-wide fishery health regulations after 1992, extended the measures enacted soon after the nematode scare. In addition to requirements for immediate gutting and freezing of fish, the regulations specify, among other things, that: 1) Parts of fish which contain live or dead nematodes must be removed immediately, and may not be sold to consumers. (One exception to this regulation is smoked herring, where the seller must indicate in writing that the fish may contain dead nematodes.); 2) Edible fishery products must contain less than 200 mg per kg of histamines; and 3) Shellfish must contain less than 400 μg per kg of alginic toxins.

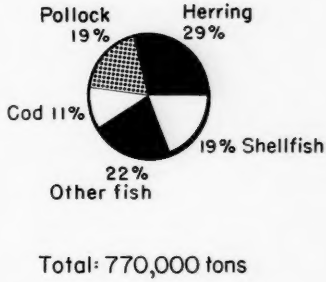

Figure 2.—FRG market for fishery products, by quantity, 1988.

The Fisheries Market

The "post-nematode" market for fishery products in the FRG appears to be undergoing profound changes, but certain basic features remain unaltered. Despite growing diversity in the FRG market, the 3 leading species—herring, pollock, and cod—still account for almost 60 percent of consumption, by quantity (Fig. 2). Herring dominates the market. Herring consumption—over 250,000 t in 1986—declined to 216,000 t in 1987 after the nematode scare but increased again in 1988 to 225,000 t. In 1988, West Germans consumed 148,000 t of pollock (saithe) and 83,000 t of cod. Other popular species included tuna (63,000 t), redfish (56,000 t), and hake (53,000 t).

The changes in the FRG fisheries market have not yet transformed consumption figures, but two new trends are clear.

First, formerly conservative German consumers are demanding a wider variety of fishery products—including higher-priced items. Because of the change in the mix of products being sold, the value of fishery products consumed is probably increasing more rapidly than indicated by the per capita consumption figures. Second, in the wake of the nematode crisis, consumers are very particular about the quality and origin of the fishery products that they buy.

The FRG fresh fisheries market—accounting for about half of total fisheries consumption—is moving to accommodate changing market conditions. Many small retailers now carry specialty fresh fish—including salmon, trout, monkfish, sea bream, and sea catfish—alongside better known species such as cod, redfish, pollock, and plaice. Suppliers of fish have felt the need to diversify. Some retailers now carry several varieties of fresh shellfish. Of the 147,000 t of shellfish consumed in 1988, the most important products were mussels, shrimp, and squid. Many German consumers are willing to pay a premium for lobster, shrimp, mussels, and crawfish. One FRG company that used to supply only herring, has switched to production of fish and shellfish salads, a type of product which is growing in popularity.

Restaurants are offering more varied and more international fish menus, catering to the many Germans who have traveled abroad. For all fresh products, assurance of quality is essential. Some retail displays list the origin (where the fish was caught) alongside the name of the product. The leading FRG trade publication, *Fischmagazin*, has stressed these changes in the fresh fisheries market, pointing out that both traditional and specialty fresh fishery products now need to be carefully presented as environmentally pure, high-quality items.

Sales of frozen fishery products in the FRG—both as convenience foods and specialty dishes—accounted for about 20 percent of the fisheries market in 1988. Large supermarkets and department stores offer many varieties of frozen fishery products, both unprocessed and prepared as meals. German consumers purchase frozen cod, plaice, pollock, mackerel, redfish, and haddock mostly as fillets. One deep-freezing plant supplies convenient, ready-to-cook frozen fish products. On the other hand, the FRG's largest fisheries wholesaler has focused partly on the specialty side of the market with a 50-item series billed as "Fish specialties from France."

While fresh and frozen fishery products are growing more popular, canned and preserved products are losing ground. The share of canned and preserved products—including canned tuna, herring packed in tomato sauce, and sardines packed in oil—declined from 33 percent of total consumption in 1987 to 29 percent in 1988. In this product category, fishery companies are responding to changing German tastes by packing herring and other fish in a variety of sauces and marinades. Smoked fishery products—mostly herring and eels—continue to hold about 6 percent of the market.

Imports

As West Germany's domestic catch has declined, its consumption of fishery products has increased (Fig. 3). FRG fishery imports reached $1.2 billion in 1988 and accounted for three-fourths of consumption, by quantity. The FRG imports substantial quantities of a wide variety of fishery products (Table 1). In 1987, imports supplied high percentages of the FRG's two most important species: 94 percent of its herring and 60 percent of its pollock supply.

EC Imports

The European Community supplied over half (by value) of the $1.1 billion of fishery imports into the FRG in 1987, the latest year for which detailed data were available (Fig. 4 and Table 2). Proximity and lack of tariffs for intra-EC trade are obvious advantages for EC nations which export to the FRG. As the EC prepares for the single market in 1992, intra-EC trade is being facilitated even further. Health regulations for fishery products are being standardized (following the example of the regulations introduced in the FRG), and deliveries of fishery products across borders are becoming less complicated.

The consolidation of the EC will continue to favor two of the largest suppliers of fishery products to the FRG—Denmark and the Netherlands. West Germany imported 115,000 t of fishery products worth $284 million from Denmark in 1987. The largest import, by quantity, was (mostly fresh) herring, which declined from 49,000 t, worth $36 million in 1986, to 37,000 t, worth $26 million in 1987. High-value imports from Denmark included whole frozen fish (16,000 t, worth $34 million) frozen fillets (12,000 t, worth $35 million) and salted, dried, or smoked fish (3,000 t, worth $45 million).

As these figures show, Denmark is an

Table 1.—FRG edible fishery imports, by quantity in metric tons and by value in U.S. dollars, 1986-87.

	Imports			
	1986		1987	
Product category	1,000 t	$1,000	1,000 t	$1,000
Fish				
Herring				
Fresh, frozen	98	52,701	81	52,321
Salted	12	13,469	10	13,338
Freshwater				
Fresh, frozen	34	131,954	36	172,655
Other				
Whole, fresh	76	115,137	70	131,720
Whole, frozen	31	41,530	31	57,355
Fillets, fresh	10	23,240	7	22,650
Fillets, frozen	90	162,210	83	186,412
Salted, dried, smoked	12	57,033	11	78,401
Canned	63	152,433	65	176,130
Other	1	13,437	1	16,146
Subtotal	427	763,144	395	907,128
Shellfish				
All types				
Fresh, frozen, dried	36	81,380	24	98,402
Canned	14	69,182	13	90,333
Subtotal	50	150,562	37	188,735
Grand total	477	913,706	433	1,095,863

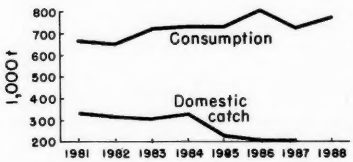

Figure 3.—FRG fisheries consumption compared with domestic catch, 1981-88.

Table 2.—FRG edible fishery imports by country of origin and value in hundreds of Deutschemarks and U.S. dollars, 1986-87.

Country of origin	1986 1,000 DM[1]	1986 $1,000	1987 1,000 DM	1987 $1,000
EC				
Denmark	526,948	243,745	510,391	284,427
Netherlands	225,537	104,324	205,718	114,641
France	104,675	48,418	104,288	58,117
UK	45,359	20,981	47,935	26,713
Italy	38,270	17,702	35,946	20,032
Ireland	29,742	13,758	30,403	16,943
Spain	26,367	12,196	27,660	15,414
Belg./Lux.	25,610	11,846	26,276	14,643
Portugal	32,069	14,834	20,699	11,535
Greece	5,402	2,499	5,506	3,068
Subtotal	1,059,978	490,302	1,014,822	565,532
Non-EC				
Norway	207,773	96,107	203,744	113,541
Iceland	139,083	64,334	145,848	81,277
Faroe Isl.	69,359	32,083	66,155	36,866
Poland	62,768	29,034	65,253	36,364
Canada	44,539	20,602	48,717	27,149
U.S.A.	17,142	7,929	23,665	13,188
Morocco	22,355	10,340	22,061	12,294
Sweden	18,648	8,626	15,970	8,900
Argentina	18,774	8,684	12,783	7,124
USSR	18,508	8,561	12,366	6,891
Japan	9,290	4,297	10,006	5,576
Yugoslavia	2,617	1,210	3,989	2,223
Other	284,495	131,596	321,100	178,940
Subtotal	915,351	423,404	951,655	530,331
Grand total	1,975,329	913,706	1,966,478	1,095,863

[1]DM (Deutschemarks) 1986 $1 = 2.162 DM; 1987 $1 = 1.794 DM.

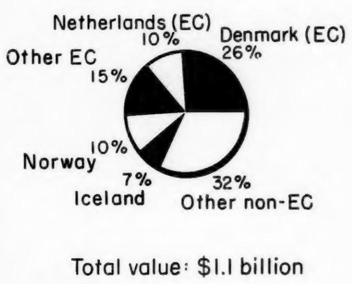

Figure 4.—FRG edible fishery imports by value and country of origin, 1987.

important source of value-added fishery products. For example, Danish processors purchase salmon of low production quality from Norwegian fish farmers; the salmon is then smoked and exported to West Germany, where it sells at reasonable prices compared to top-quality Norwegian farmed salmon. Denmark also supplied over 14,000 t of trout to West Germany in 1987.

West Germany imports many of the same fishery products from the Netherlands as it does from Denmark. Of the 50,000 t of imports worth $115 million from the Netherlands in 1987, 12,000 t, worth $36 million, were whole frozen fish; 15,000 t, worth $7 million, were herring; 2,000 t, worth $9 million, were frozen filets; and 2,000 t, worth $6 million, were salted, dried, or smoked fish. Salted herring (7,000 t worth $10 million) and shellfish (3,000 t worth $10 million) were also important.

The Netherlands is the FRG's most important supplier of "Matjes," the name for a delicacy made with cured and pickled fresh herring. Recently, the Government of the Netherlands (with assistance from the EC) approved a 5-year, $3.4 million marketing effort for Dutch herring. The effort will focus primarily on West Germany, where millions of consumers will receive promotional materials and recipe brochures touting fresh, parasite-free herring from the Netherlands.

Like firms in other EC nations, Dutch companies have facilitated their access to the German market by establishing subsidiaries in the FRG. One interesting example of this phenomenon is a Dutch company established in the FRG to import specialties from Chile—shrimp, king crabs, salmon, and trout.

Within the EC, West Germany's third and fourth largest suppliers of fishery products are France (23,000 t worth $58 million in 1987) and the United Kingdom (6,000 t worth $27 million). The FRG imported $26 million (9,000 t) of whole fresh fish, and $21 million (2,000 t) of shellfish from France. The United Kingdom supplied $12 million worth of fresh and frozen whole fish, including 4,000 t of pollock. The FRG imported $8 million worth (1,500 t) of freshwater fish from Italy and $5 million (7,000 t) worth of (mostly frozen) herring from Ireland.

Non-EC Imports

West Germany's most important "third country" (non-EC) suppliers of fishery products are, not surprisingly, other nearby European nations: Norway, Iceland, the Faroe Islands, and Poland. Norway (which qualifies for reduced tariffs because of its fishing agreements with the EC) dominates this market. Like Denmark and the Netherlands, Norway supplies a large quantity of herring to the FRG—13,000 t worth $8 million in 1987. Norway also supplies frozen fish filets (15,000 t worth $8 million) and fresh farmed salmon (5,000 t worth $39 million). To ensure a presence in the FRG market after 1992, Norwegian fishery companies have joined Denmark, France, and the Netherlands in establishing subsidiaries in West Germany.

Iceland, second to Norway among non-EC exporters to the FRG, supplies a significant amount of whole fresh fish to the FRG (28,000 t worth $35 million in 1987). Iceland was the FRG's single largest supplier of redfish (18,000 t or three-quarters of FRG imports) and pollock (5,000 t or one-quarter of FRG imports). Iceland also supplies herring and halibut. The Faroe Islands and Poland both supplied part of the FRG's large market for frozen fish fillets, primarily hake and pollock.

The largest non-European supplier of fishery products to the FRG is Canada, with 10,000 t of exports worth $27 million in 1987. Shellfish (600 t worth $7 million) led Canadian exports to the FRG, followed by frozen salmon (1,000 t worth $5 million), and herring (6,000 t worth $4 million).

The United States was the FRG's fourteenth largest supplier of fishery products in 1987, the latest year for which statistics were available from German sources, accounting for only about 1 percent of FRG imports (Table 2). While U.S. exports make up a small proportion of German imports, these exports have increased significantly in recent years, from $7.9 million in 1985 to $12.6 million in 1988 (Table 3).

Salmon dominates U.S. exports to Germany, accounting for over 40 percent of the value of U.S. exports in 1988. As indicated in Table 3, the bulk of such salmon exports consist of chum and pink salmon, which are priced lower than sockeye or chinook salmon because of their smaller size and softer flesh. In

Table 3.—FRG edible fishery imports from the United States, by product and value, 1985-1988[1].

Product	Imports (US$1,000) 1985	1986	1987	1988
Fish				
Salmon, frozen				
Chum	3,719	2,768	2,034	2,643
Pink	20	29	333	1,078
Sockeye	119	230	1,056	339
Silver	0	141	50	31
Chinook	1	0	241	6
Steaks[2]	845	326	812	241
Subtotal	(4,704)	(3,494)	(4,526)	(4,338)
Salmon, other				
Roe	733	1,663	2,167	2,047
Canned	22	67	134	178
(Salmon, total)	(5,459)	(5,224)	(6,827)	(6,563)
Alaska pollock	0	418	867	325
Eels	368	236	356	318
Halibut fillets	0	192	26	109
Cod	0	0	128	0
Other fish	1,648	1,242	2,104	3,466
Subtotal	7,475	7,312	10,306	10,781
Shellfish				
Squid				
Loligo	0	68	17	688
Other	337	137	203	187
Crabs, Alaskan	33	84	326	259
Shrimp	2	26	243	293
Lobster	0	0	90	101
Sea urchin	0	0	0	17
Other shellfish	13	70	332	246
Subtotal	385	383	1,211	1,791
Grand total	7,860	7,695	11,517	12,572

[1]Source: U.S. Bureau of the Census. There is a discrepancy (about 14 percent) between these totals and those reported in the "Annual Report on German Fisheries, 1987/1988."
[2]Mostly from chum salmon.

1988, there was an abundance of chum salmon (also used for salmon steaks and for salmon roe), prompting exporters to market large quantities in Germany. In contrast, the bulk of sockeye salmon landed in Alaska is shipped directly to Japan, so there are relatively small quantities available for export to Europe.

Table 4.—Selected FRG fishery imports from the United States, compared with the imports from the largest suppliers, by value in thousands of U.S. dollars, 1987.

Product	Country of origin: United States	Largest Suppliers	
Frozen salmon	4,526	Canada	5,000
		Denmark	4,000
		Norway	3,000
		Total	16,600
Eels	356	Denmark	10,000
		Netherlands	5,000
		Total	35,000
Squid			
Loligo	17	Thailand	2,000
Other	203	Spain	300
		Total	7,800
Shrimp	243	Netherlands	9,000
		Bangladesh	7,000
		Thailand	5,000
		China	3,000
		Total	50,000
Lobster[1]	90	Canada	1,000
		France	250
		Total	3,000

[1]Includes live, whole frozen, pieces frozen; exports from France are Norway lobsters.

Frozen salmon exports from the United States compete with those from Canada, Denmark, and Norway (Table 4).

Other important U.S. exports include squid, shrimp, and Alaskan crabs. Both squid and shrimp exports from the United States compete with much larger exports from Thailand (in both cases), the Netherlands, Bangladesh and China (in the case of shrimp). U.S. squid exports, though small compared with total FRG imports, surged from $0.2 million in 1987 to $0.9 million in 1988, reflecting the large increase in the U.S. squid catch (from 37,000 t in 1987 to 58,000 t in 1988), as well as other world squid market factors. Both squid and shrimp from countries such as Thailand are generally lower priced than equivalent exports from the United States. In addition, products from such developing countries face preferential tariffs when entering the EC market. For example, processed shrimp from the United States is charged a tariff of 20 percent, compared with 6 percent in the case of Thailand or Bangladesh.

U.S. Export Opportunities

The U.S. Foreign Commercial Service reports that the following products have good sales prospects in the FRG market: Alaska pollock (considered a good substitute for cod), lobster, jumbo shrimp, oysters, and mussels. Alaska pollock exports declined in 1988, despite the fact that the U.S. catch of the species more than doubled. This fluctuation may reflect the relative price and supply of cod—1988 import figures for Germany were not yet available.

The heavy promotion of lobster from the United States at the 1987 ANUGA food trade fair in Cologne, West Germany, probably accounts for the expanded sales of this product in 1987-88 (Table 3). At the 1989 ANUGA fair, 5 (out of 37) U.S. exporters again displayed lobsters. A U.S. company is reportedly providing holding tanks to German seafood stores and supermarkets, opening up the possibility of live lobster sales in Germany. Lobsters would be flown directly from New England to Germany. The German lobster market (Table 4) is strongest around the Christmas holidays. (Source: IFR-89/98, prepared by Brian D. McFeeters.

Japan's Driftnet Fisheries Conflict With Squid Jiggers

Japanese fishermen conduct extensive driftnet fishing operations within Japan's Exclusive Economic Zone (EEZ), mostly using large numbers of small vessels with short nets. However, large-scale salmon, tuna, and billfish driftnet fisheries also operate within the EEZ. Large-scale Japanese squid driftnet fishing began in 1978 in an area overlapping the Japanese 200-mile zone and the high seas. Squid driftnetting was prohibited in that area by the Japanese Government after complaints by squid jigging fishermen that they could not operate profitably in competition with driftnetters in the same area—an area the squid jiggers had occupied first. To resolve the conflict, the Government separated the two groups by establishing a separate squid driftnetting area outside the jigging area. Japan's only domestic conflicts over driftnet fishing have been the result of economic competition between highly regulated fisheries.

Background

Japanese fishermen have used driftnets in Japanese waters under prefectural license for about 100 years. Currently, driftnets are legally used to catch nearly all surface-feeding fish in Japanese waters—sardines, saury, Spanish mackerel, mackerel, "kisu" (silver whiting, *Sillago japonica*), "managatsuo" (similar to butterfish), flying fish, and sea bass, to name a few. A very important exception is squid (discused later). In addition, large-scale driftnets (<0.5 km) are used under license from Japan's Ministry of Agriculture, Forestry and Fisheries (MAFF) to fish for salmon, tuna, and marlin, both inside and outside the Japanese EEZ.

The total number of driftnet vessels operating within Japan's 200-mile zone can only be roughly estimated. The coastal prefectures issue fishing permits, by species, to any vessel under 20 gross tons that fishes with driftnets. Because these vessels may fish for several species, each vessel may hold multiple permits. The number of vessels permitted by the prefectures is unknown but the Fisheries Agency of Japan (FAJ) estimates it to be in the thousands, possibly as high as ten thousand. The typical fishing vessel licensed by the prefectures is small—usually less than 10 tons. Consequently the length of their driftnets, although not restricted by law, usually ranges from 100 to 1,000 m.

Large-scale driftnetters, on the other hand, are licensed by the MAFF. There are about 900 vessels that fish for salmon, tuna, and billfish. The exact number of driftnet vessels in the 1989 large-mesh tuna and billfish fishery is not yet known (vessel registration only began 1 August 1989, and was still open for applications), but will likely reach 460, the number estimated in 1987. The Japanese Government permits 440 vessels to fish for salmon with driftnets within its EEZ. In summary, there are about 900 large-scale driftnetters and perhaps as many as 9,000-10,000 small-scale driftnetters fishing in Japanese waters.

Net Lengths

The nets used by salmon driftnet vessels fishing within the 200-mile zone are limited to lengths of <10 km, whereas the limit outside the EEZ is 15 km. Nets used in the large-mesh tuna and billfish fishery are not limited and the vessels fish the same nets inside the Japanese EEZ that they use on both the North and South Pacific high seas. These nets may be from 30 to 50 km long.

Squid Driftnet Fishing

Large-scale Japanese squid jigging operations had been concentrated in one area of the North Pacific since 1975—lat. 40-44°N by long. 144-156°E, half inside the Japanese EEZ. Beginning in 1978, other fishermen (trawlers, salmon fishermen, and longliners forced out of the Soviet 200-mile zone as a result of Japanese-Soviet fishery negotiations) began using driftnets to catch squid in the same area. The relatively high catch rates of the driftnetters, compared with the jiggers, caused complaints from the jiggers. They argued that the concentrations of squid necessary for jigging to be profitable would be quickly reduced by driftnetting operations. They would not be able to operate profitably if they had to share the grounds with the driftnetters, who did not need such concentrated squid catches to make a profit. The jiggers had originally discovered the squid grounds, which were inside a larger area to which their jigging operations were restricted. The driftnetters, however, did not face the same fishing area restrictions as the jiggers.

Resolution

The conflict was resolved when the FAJ separated the two groups by requiring squid driftnet fishermen to operate south of lat. 40°N and east of long. 170°E (the jigging area north of lat. 20°N and west of long. 170°E) under a Ministry licensing system established in 1981. (The lat. 40°N limit is to prevent salmon interception and is seasonally extended northward as the salmon move north.) Conservation was not the reason driftnetters were forced out of the area. Flying squid (red squid or "aka ika", in Japanese) live less than 2 years and are only caught by both driftnetters and jiggers at the end of their life cycle. (Source: IFR-89/102, prepared by Paul E. Niemeier, Foreign Affairs Specialist, Foreign Fisheries Analysis Branch, National Marine Fisheries Service, NOAA, Silver Spring, MD 20910.

Japan's Recreational Boating and Fishing

Recreational boating in Japan is gradually expanding as a result of increasing affluence, but remains a leisure industry far below its potential. The stimulus that recreational fishing and the proliferation of marinas could impart is effectively thwarted by Japan's land-use laws, commercial fishing rights, restrictions on gear types, and compensation requirements. These combine to preclude not only legal recreational fishing, but also the development of facilities necessary to support such activity.

For nearly 400 years, fishing in Japanese waters was the vested right of commercial fishermen. The notion of fishing for fun was juridically acknowledged for the first time in 1972 when the Fisheries Agency of Japan (FAJ) charged the prefectural governments with the regulation of recreational fishing. But, under heavy pressure from commercial fishermen to keep recreational fishing from interfering with their normal operations, the prefectures restricted recreational fishing activities to the most basic methods. Japan revised its fisheries laws again on 1 October 1989 to expand opportunities for recreational fishermen. Yet, absent a radical reorientation of attitude toward coastal development, the current change will do little to stimulate boating or fishing as leisure sports in Japan.

Regulations and Custom

Fishing in Japanese waters has traditionally been the sole domain of commercial fishermen. Until 1972, in fact, recreational saltwater fishing was illegal. Even now, it is a pastime existing on the margin and at the sufferance of the important and politically-powerful commercial fishing industry. A complex web of federal and prefectural fishing regulations, buttressed by custom, tightly restrict yachting and fishing. The practical result is that commercial fishermen control the right to fish and, so far, have been willing to tolerate only a rudimentary form of charter boat fishing.

The Government of Japan (GOJ), through its Ministry of Agriculture, Forestry, and Fisheries (MAFF), issues fishing permits to commercial fishermen. The permits grant the right to engage in fishing as a business, but do not confer exclusive fishing rights or legal property rights. However, because permits are necessary to own fishing vessels and because they can be inherited, they are treated as private property. Permits are routinely bought and sold for substantial sums.

Prefectural Governments

In addition to issuing permits, MAFF delegates to the prefectural governments the right to organize cooperatives which control (by area limits or gear type restrictions) all fishing activity within the prefecture. Invariably all licensed fishermen must belong to one of these cooperatives and membership is selectively limited (e.g., by stipulations that all members must live in a specific area, or must fish using some specified gear type). Similar types of cooperatives (e.g., trap net fishermen, squid driftnet fishermen, tuna longline fishermen, etc.) are organized into national federations. The federations, in aggregate, represent and effectively control all Japanese commercial fishing activity.

Through the system described above, the number of fishermen, fishing areas, and type of fishing have been tightly controlled for many years. In the postwar years, when growing numbers of people began to hire commercial fishermen to take them sport fishing, the natural response of the bureaucracy was to seek an accommodation that assured harmony between commercial and recreational fishermen. Thus, it became necessary to acknowledge this technically-illegal activity in order to regulate it. The MAFF authorized Japan's prefectural governments in 1972 to allow recreational fishing under conditions specified by local authorities. Naive observers might have expected a consequent boom in recreational fishing and boating. Not surprisingly (in view of the local political influence of the fishermens' cooperatives), however, the prefectures uniformly adopted regulations which allow only the most rudimentary forms of recreational fishing. For example, recreational fishermen may use boats only for stationary hook-and-line fishing. Trolling, the foundation of the multi-billion dollar American boating industry, is specifically prohibited in Japan except for Hokkaido, where an experimental salmon troll fishery has been permitted since 1988 to see if a recreational fishery can be developed.

Chartered Vessels

The practical consequence of the circumstances described above has been the proliferation of recreational fishing using chartered vessels which are licensed simply for transportation. Though it remains small in scale by U.S. standards, charter-boat fishing is growing so fast that the Japanese Diet passed a law in December 1988, to "Normalize Recreational Fishing." The new law, which went into effect on 1 October 1989, requires that all owners of chartered recreational fishing vessels register their vessels and provide the government with information on their businesses. Boats used privately by the owner need not be registered but they also are limited to fishing under the conditions noted above. The new law aims at documenting the impact of sport fishing and assuring that it does not develop to the detriment of commercial fishermen. It offers little to encourage the expansion of recreational boating in Japan.

Structural Impediments to Recreational Boating

In addition to fishing regulations, Japan's land-use laws and customs support commercial fishing to the exclusion of sport fishing. These combine to

severely inhibit the development of port facilities and other infrastructure that support a sport fishing industry. Nearly every meter of Japan's extensive coastline is owned or controlled by government entities. All port areas are reserved for the use of either the transport industry (under Transport Ministry supervision), or the fishing industry (under MAFF supervision). Other coastal land (50 m shoreward and 50 m seaward) is owned by national or prefectural governments.

Japan's Fishing Port and Harbor Law (Law No. 137 of 1950) authorizes the Minister of Agriculture to designate fishing ports and to permit construction of structures and/or use of the sea surface in areas so designated. MAFF delegates this authority to the prefectural governments and the prefectures in turn delegate the cities and towns for the public benefit. All land use in fishing ports, therefore, is ultimately subject to the approval not only of MAFF, but also of prefectural and municipal governments. The latter are especially sensitive to the needs of well established local commercial fishing interests. Consequently, private development of land within a port and harbor area is virtually impossible. The required approvals by local, prefectural, and national authorities assure that only public development necessary to satisfy local demand is allowed, and that local constituent groups have effective veto power. Recreational facilities such as marinas and yacht harbors can be developed only if recreational fishing is seen as a boon to the local economy and to the established commercial fishing industry. In addition, even if the commercial fishing industry became convinced of the desirability of recreational fishing, an elaborate system of compensation for "lost revenue" (including "lost opportunity") makes development of recreational facilities prohibitively expensive. For example, a large GOJ-sponsored marine resort project in Tokyo Bay is currently stalled in negotiations with commercial fishing groups over compensation.

Conclusions

Japanese fisheries census statistics show that the number of "recreational fishing experiences" (both fresh and salt water) grew from 2 million in 1977 to 31 million in 1983 to 35 million in 1988. The number of noncommercial fishing vessels (both charter and private) only increased from 74,549 in 1983 to 115,863 by 1988. It is clear that consumer demand for recreational fishing opportunities is high. Yet the development of its corollary—private recreational boating ("my boat" in Japanese)—has been stunted by strict fishing laws and lack of facilities. Complex regulations have provided effective political cover for commercial fishing interests which are almost uniformly antipathetic to development of a recreational boating industry.

Once again, the interests of Japanese consumers and would-be American exporters are in happy coincidence. Freed of artificial constraints, the potential for development of yachting, power boating, and recreational fishing in all its forms in Japan is almost limitless. Development of recreational boating and fishing on a Western scale and along Western lines could be a boon for Japan's economically depressed fishing ports and their populations. Two steps are essential to create a situation where everybody wins: 1) Widespread legal tolerance of trolling and other boating activities considered normal elsewhere in the world and 2) revision of land-use laws and development practices to facilitate development of boating and marine recreation facilities. (Source: IFR-90/10, prepared by Todd T. Schneider, Foreign Affairs Specialist, Office of International Affairs, NMFS, NOAA, Silver Spring, Md 20910.

Chile's Salmon Culture Industry

Salmon culture is Chile's fastest growing economic activity. At current growth rates, the salmon culture industry could well become the leading sector of the country's dynamic fishing industry, supplanting Chile's massive fishmeal industry. Chilean salmon farmers expected to harvest over 16,000 metric tons (t) in 1990, double the estimated 7,500 t harvested in 1989 (Table 1). Salmon culture is a new industry in Chile and farmers only achieved harvests of more than 1,000 t in 1986. Several large foreign companies have subsequently entered the industry, permitting the substantial increases now being reported.

The participation of some of the major salmon culture companies in Norway, the U.K., and Japan has meant an infusion of technology and capital which is enabling the Chilean industry to emerge rapidly from small scale operations to an increasingly important sector of the country's fishing industry. Some observers believe that harvests by 1993 could be close to 30,000 t, and that the Chilean industry will eventually rival the massive Norwegian industry which currently harvests about 150,000 t annually. The Chilean coast is similar to the Norwegian coast, and there are large numbers of well sheltered potential sights for expansion along the coast south of Chiloe Island where the industry is now centered.

Yields

Farmers are reporting excellent yields with growth rates exceeding some of the best Scottish and Norwegian operations, at least partially due to the warmer water temperatures in the Chiloe area. Chilean production costs are generally below those of their major competitors, primarily because of lower feed costs. The industry initially cultured coho salmon, but the involvement of Norwegian and British companies has made possible diversification into Atlantic salmon. Many

Table 1.—Chilean salmon harvests, 1981-89, in metric tons.

	Pacific salmon			Atlantic	Sea-farmed	
Year	Chinook	Coho	Cherry	salmon	trout	Total
1981		1				1[1]
1982		184				184
1983		94				94
1984		109				109
1985		500				500
1986		1,144				1,144
1987		1,780		41		1,821
1988	3	4,075		165	100	4,343
1989E[2]	50	5,300		1,320	870	7,540
1990P[3]	200	9,900	75	4,950	1,500	16,625
1991P	300	13,900	75	7,100	2,000	23,375
1992P	700	14,700	75	8,500	2,500	26,475
1993P	1,000	16,300	75	8,000	3,000	28,375

[1]Some sources report harvests of up to 70 mt in 1981.
[2]E = Estimated.
[3]P = Projected. Note: Various sources offer widely different projections on future Chilean harvests. The 1990-93 data in this table should be viewed as very rough projections of harvest levels.

farmers are also working with chinook salmon and sea-farmed trout ("salmon-trout"). Eventually harvests of sockeye and cherry salmon are also possible.

Markets

Farmers initially marketed their harvests largely fresh in the United States, but since 1988 they have shifted coho exports primarily to Japan, mostly shipped frozen (Table 2). The increasing production of Atlantic salmon is mostly air-freighted fresh to the United States. Prospects for European sales are less clear because of relatively high freight charges to Europe and competition with European producers. Some officials are concerned over problems such as "brown-tide" outbreaks and a still untreatable disease which affects primarily cohos. Many farmers are also concerned about the impact of the steadily increasing world supply of farmed salmon on prices. Some industry leaders believe that Chilean farmers may be expanding their operations too rapidly before the impact of increasing world production on the future price structure is clearly understood. A recent market analysis (GLOBEFISH Research Programme, Volume 1) suggests that rising demand and a variety of other factors will prevent any precipitous price decline. Even in an environment of declining prices, however, Chilean producers are well situated to compete successfully because of their low cost structure, high quality standards, species diversification, and successful penetration of both the Japanese and U.S. markets. (Source: IFR-90/02.)

Table 2.—Chile's salmon and trout exports to principal markets, 1980-89, in metric tons.

	Japan		U.S.		E.C.	
Year	Salmon	Trout[1]	Salmon	Trout	Salmon	Trout
1980						140
1981	5				96	164
1982	51				28	143
1983	33			70		70
1984			32	73		117
1985			155	30		413
1986	45		743	108		483
1987	28		1,173	48		449
1988	1,064		1,588	166	N.A.[2]	N.A.
1989[3]	(3,662)	(258)	(783)	(68)	N.A.	N.A.

[1]Separate data for trout not available before 1987. Trout data includes both sea and freshwater operations.
[2]N.A. = Not available.
[3]January to June

Ecuador's Shrimp Culture Industry

Ecuadorean press reports suggest that 1990 will not be a good year for shrimp farmers. The country's farmers reported lower shrimp shipments in 1989 and prospects for 1990 were not encouraging, although farmers did report higher November shipments. The country's troubled shrimp industry encountered significant difficulties in 1989. Many of these problems related to environmental conditions which may become increasing severe in coming years.

Ecuadorean shrimp farmers exported 41,200 metric tons (t) of shrimp in 1989 (through November) about 12 percent less than during the same period of 1988. Ecuador's major export market is the United States and most of the decline has been due to lower U.S. shipments. Ecuadorean exports to European countries, on the other hand, have been generally stable or increasing. While overall shipments are lower, farmers reported improved results in November. Shipments in November alone totaled 4,300 t, about 12 percent above 1988 shipments. It is not yet known whether this increase portends any change in the overall declining production trend.

Farmers reported several new problems in 1989 as well as intensifying long term problems. Many of these problems relate to environmental quality, a tendency which does not auger well for the industry's future.

The use of fertilizer to support the growth of phytoplankton on which the shrimp feed also supports the growth of other organisms. One is a protozoan which infects the gills of the shrimp. This alters the shrimp's normal negative phototropism and causes individuals to surface more frequently than normal, making them more vulnerable to sea gull predation. Farmers are now reportedly developing methods for reducing predation.

Oil spills are causing problems for both farmers and hatchery operators. Hatcheries on the Santa Elena Peninsula in Guayas Province, a major concentration of hatcheries, reported the loss of 200 million larvae worth about $1 million due to spills from the Peninsula oil terminal that contaminated coastal waters. Losses of wild larvae and other ecological damage in the region was probably substantially larger.

Shrimp fishermen in the Gulf of Guayaquil complained of losses resulting from the overburdening of the Gulf ecosystem with organic material, sewage from Guayaquil and agricultural runoff from the Guayas River basin. The problem was particularly severe in 1989 because of unusually low rainfall and diversion of water from the Guayas River for agriculture which has expanded significantly in recent years. Shrimp farmers also require substantial quantities of water. The problem is compounded by dredging in the Gulf shipping lanes.

Despite the problems being reported in the press, individual shrimp farmers were still optimistic about the industry's future. While competition from China and other Asian producers is an increasing problem, industry experts are convinced that Ecuador has a strong competitive position. Ecuadorean farmers enjoy perhaps the most ideal growing

conditions available in the world and should theoretically be able to compete with any other country. Many believe that China's success on world markets is based on exporting at prices below actual production costs resulting from the need to generate hard currency earnings.

Local observers believe that once Ecuadorean farmers learn how to handle hatchery-produced larvae, major production increases are possible. In addition, the anticipated poor availability of wild larvae in 1990 will probably provide a strong market for the country's inadequately financed hatchery industry. A year of strong profits could enable several hatcheries to stabilize their finances as well as improve their production methods. Eventually, normal climatic fluctuations will increase the availability of wild larvae. While this will assist farmers, it makes it difficult to operate a stable hatchery industry. Once established, however, a financially stable hatchery industry combined with continued improvements in growing methods should allow farmers to increase production in 1991 or 1992.

What most concerns farmers is the impact of increasing world shrimp supplies on prices. While Ecuadorean farmers are convinced that they can compete with farmers in other countries, international shrimp prices in real terms have declined by about 50 percent since 1980. The margins of even efficient Ecuadorean farmers have been significantly narrowed. Farmers are concerned that further major price declines could seriously affect the industry's future. (Source: IFR-90/08.)

Colombia Inaugurates Tuna Processing Plant

Colombian President Virgilio Barco inaugurated the new FRIGOPESCA[1] tuna processing plant in the Caribbean port city of Cartagena on 14 January 1990. The plant is located in Cartagena's Mamonal Industrial Zone (MIZ). Tuna caught in the Pacific Ocean is being landed at the plant for cooking, deboning, and cleaning, after which it is frozen and shipped to a U.S. tuna cannery in Mayaguez, Puerto Rico.

FRIGOPESCA was created in 1983 from FRIGOCAR, a company founded in 1975 to slaughter beef and export meat products to the European Economic Community (EEC). The EEC restricted access to Colombian beef, however, because of hoof and mouth infestation and FRIGOCAR was unable to export as planned. The FRIGOCAR plant processed only 200 t of beef in 1989, all of which was consumed domestically. FRIGOPESCA investors decided that fishery operations could provide an alternative use for the costly facilities built by FRIGOCAR. Colombia has barely begun to tap its tuna and other marine fishery resources. Investors recognized the potential export and domestic market for seafood.

FRIGOPESCA signed a contract with a U.S. tuna company in 1989. The U.S. company reportedly agreed to provide the technology required to develop a tuna processing plant and buy all the tuna processed by FRIGOPESCA. The project converting FRIGOCAR facilities cost about $2 million, about half of which was put up by a Colombian development promotion group (IFI) and the Santo Domingo investment group. The remainder was financed by the Banco Ganadero.

Three U.S.-flag seiners were currently catching tuna in the Pacific, including Colombian-claimed waters, for delivery to the plant. FRIGOPESCA and other tuna processing plants in the region (Ecuador and Costa Rica) take advantage of relatively low wage rates for the labor intensive operations of preparing tuna for canning. FRIGOPESCA's Cartagena plant was processing 7 t of tuna per day. The company expected to increase daily production to about 60 t per day by April or May 1990. While important to the local economy, FRIGOPESCA will only be a minor supplier to Puerto Rico where some canneries require 1,000 t of tuna daily. FRIGOPESCA employed a staff of about 150. The company will ultimately require 300 additional employees when it begins operating at full capacity. FRIGOPESCA expects the value of tuna exports to increase from about $12.5 million in 1990 to $30.0 million by 1994.

President Barco used his opening speech as an opportunity to publicize Colombia's economic potential and criticize pessimistic economic projections. He said that the country is not paying attention to gloomy economic forecasts and that Colombia is continuing to progress despite its security and economic problems. Barco especially applauded Cartagena, calling the city one of Colombia's industrial capitals along with Bogota, Cali, and Medellin. He said Cartagena's MIZ, with its 60 participating companies, is a major growth area driving the country's economic expansion. He also noted steps taken by MIZ officials to reduce pollutants being released into Cartagena Bay.

President Barco, directly addressed Cartagena's political and business leadership at the ceremony. He listed various projects that the Departmental Government had undertaken during 1987-89 to repair/expand its road system and provide electricity to 17,500 families. He supported plans to construct a new transportation terminal in Cartagena, and promised assistance from the National Government in addressing beach erosion problems at Cartagena's Bocagrande tourist hotel area. He also expressed appreciation for the Canadian Government's plans to provide $12 million in assistance for pollution abatement efforts at "De La Virgen," a saline basin east and adjacent to Cartagena. Significant fish kills have occurred in the basin in recent years. (Source: IFR-90/06.)

Japan-Vietnam Fishery Relations

Japanese imports of Vietnamese fishery products have increased from about 5,400 metric tons (t), valued at $27 million, in 1984, to almost 20,000 t, worth nearly $100 million, in 1988. In addition, a joint fisheries venture between Japan, Vietnam, and the Soviet Union was set to begin in 1990; it will allow Japan to purchase, over-the-side, 15,000 t of Soviet-caught walleye pollock.

The value of Japan's fishery imports from Vietnam has increased an average

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

of 36 percent every year since 1983. Japan imported nearly 20,000 t of fishery products, worth about $100 million, from Vietnam in 1988 (Table 1). These imports ranked 20th, or almost 10 percent, by value, of Japan's total fishery imports in 1988. The largest commodity Japan imported from Vietnam was frozen shrimp. In 1988, Vietnam supplied nearly 3 percent of Japan's $2.6 billion shrimp imports and was the ninth largest supplier of this commodity. A total of 11,500 t was bought by Japan for $76 million, or about 78 percent of the total value of Japan's fishery imports from Vietnam. Other commodities purchased from Vietnam were frozen cuttlefish ("Mongo-ika") (1,252 t, worth $5.8 million), and dried cuttlefish (274 t, valued at $2.6 million). Japan did not export any fishery commodities to Vietnam in 1988.

Table 1.—Japanese imports of Vietnamese fishery products by commodity, quantity, and value, 1984-88.

	Imports									
	1984		1985		1986		1987		1988	
Commodity	t	$1,000	t	$1,000	t	$1,000	t	$1,000	t	$1,000
Frozen shrimp	5,104	26,210	6,974	32,791	9,361	44,898	11,743	62,168	16,475	76,129
Frozen cuttlefish	242	851	540	1,923	651	2,567	915	3,849	1,252	5,774
Dried cuttlefish	0	0	44	165	531	2,893	599	4,036	274	2,596
Other	57	189	124	399	270	1,244	1,000	5,353	1,963	13,711
Total	5,403	27,250	7,682	35,278	10,813	51,602	14,257	75,406	19,964	98,101

Japan planned to purchase in 1990 pollock over-the-side from Soviet fishermen off western Kamchatka Peninsula through a joint venture with the Soviet Union and Vietnam. Japan will be utilizing a pollock catch quota granted by the Soviet Union to a Vietnamese firm.

To speed up economic rehabilitation, Vietnam's Sea Product Export Corporation (SEAPRODEX)[1] established the joint venture "SEASAFICO" in 1988 with the Soviet Union's Sakhalin Fisheries Kolkhoz (cooperative). The Sakhalin Kolkhoz helped SEASAFICO obtain a fishing catch quota in the Soviet 200-mile zone. On 15 January 1990, the Kita Taiheiyo Gyogyo Company (North Pacific Fishery Company), established by the Hokuten Trawlers Association (HTA) of Japan, signed an agreement with SEASAFICO to purchase its Soviet-caught pollock over-the-side. The agreement originally called for the Japanese to purchase 24,000 t (later reduced to 15,000 t) of roe-bearing pollock to be caught off western Kamchatka at a reported purchase price of $441/t. The purchase season ran from 5 February to 31 March 1990. The departure of Hokuten trawlers from Japan was postponed until 14 February 1990, because the Soviet Fisheries Ministry delayed the release of the pollock quota to SEASAFICO as well as the issuance of the subsequent fishing permits to Japanese vessels. The first contingent of three Hokuten trawlers reportedly began purchasing roe-bearing pollock on 17 February 1990, from about 10-16 Soviet trawlers off western Kamchatka. The HTA fishermen planned to purchase 600 t of pollock over a 3-day period. They would then be replaced by three other Hokuten trawlers for 3 more days. In all, 49 Hokuten trawlers were expected to participate in the purchase.

The Government of Japan announced on 23 January 1990, an additional import quota of 100,000 t of pollock to accommodate the above joint venture purchase, as well as Japan-Soviet joint venture purchases of pollock resulting from the two countries' annual bilateral groundfish agreement. The joint venture is particularly valuable to the Japanese. It provides access to Soviet fishing grounds and jobs for Japanese fishermen, especially Japan's Hokuten trawlers, which are being phased out of the Soviet zone and which have been excluded from the U.S. zone since 1988. (Source: IFR-90/26, prepared by Todd T. Schneider, Foreign Affairs Specialist, Office of International Affairs, Foreign Fisheries Analysis Branch, NMFS, NOAA, Silver Spring, Md 20910.

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

Canada Announces Fisheries Assistance

The Canadian Government has announced the highlights of a C$584 million (US$496 million) fisheries adjustment program for Atlantic Canada. Included are: 1) The rebuilding of fishery stocks by increasing surveillance and enforcement, 2) assistance for displaced fish processing workers, and 3) help in diversifying the economies of Atlantic fishing communities. The Canadian Minister of Fisheries and Oceans, Bernard Valcourt, unveiled the long-awaited package to aid the troubled Atlantic fisheries at two separate news conferences in St. Johns, Newfoundland, and in Halifax, Nova Scotia, on 7 May 1990. Valcourt announced the details of the half billion Canadian dollars package to be spent over 5 years in Nova Scotia and Newfoundland Provinces. Prince Edward Island and New Brunswick Provinces were not covered in the announced program, but Valcourt was scheduled to visit New Brunswick on 8 May and fishermen there were expecting him to reveal what assistance Ottawa intends to provide for the industry in that Province.

Of the C$584 total, C$426 million will be in newly allocated funds focused in three major programs: Rebuilding fishery stocks, "Adjusting to current realities," and Economic diversification.

Rebuilding stocks: (CS150 million). Most of this money will go to scientific research and fishery surveillance and enforcement. Canada will also intensify its diplomatic efforts with West European countries to stop fishermen of those nations from overfishing. For those found guilty of overfishing in Canadian waters, fines will go as high as C$0.5 million, a hundredfold increase over the current maximum of C$5,000. In addition, any-

one who destroys or disrupts fishery habitats may face fines of up to C$1.0 million.

"Current realities": (C$130 million). This segment of the program will provide as much as C$120 million toward extended unemployment insurance benefits and early retirement for older workers. The number of fishing licenses will also be reduced through the implementation of a mandatory certification program for fishermen called "professionalization." In addition, there is now a freeze on the issuance of new fishing licenses in all four Atlantic Provinces. (Newfoundland and Labrador had previously been exempt.)

Economic diversification: (C$146 million). This segment of the program will be administered by the Atlantic Canada Opportunities Agency. Key components include funds for the development and marketing of undertulized fishery species, the promotion of new, nonfishery industries, and research into improving product quality.

The remaining components of the adjustment program, totaling C$158 million, had been announced previously by Ottawa. In April 1990, Atlantic Airways of St. Johns, Newfoundland, was awarded a C$28-million contract to provide aerial surveillance of Canada's 200-mile limit. The balance of C$130 million will go to seven Atlantic fishery communities, three towns in Nova Scotia, and four in Newfoundland which have been hard-hit by closures of fish-processing plants. These funds will be used for retraining laid-off workers and for community development.

Valcourt acknowledged that the aid package will not solve the industry's problems overnight. He told reporters that the program is not a quick fix to the current crisis, but represented the difficult first step towards the revitalization of the Canadian Atlantic fisheries. He said that the package will pull the industry back on its feet by giving it stability and direction for long-term growth and development. According to the Minister, despite the additional funding to help fishery workers, the industry will have to be scaled back and not be used to maximize job availability as in the past. While Valcourt hopes the action plan will bring much needed stability to the troubled industry, others are not so optimistic. Most fishermen are taking a dim view of their future since another focus of the adjustment package will be a reduction in the number of Atlantic Canadians who make their living from the fishing industry.

Ottawa's blueprint for a streamlined fishery received a generally negative reaction from community leaders, fishermen, and politicians. There were critical comparisons of the aid package to the C$1 billion that Ottawa gave drought-stricken western grain farmers in 1988. Others connected to the fishery are pondering how the extra funding to diversify the economy will help their communities. Towns like Canso, Nova Scotia, one of several towns that have been devasted by the downturn in the industry, have been trying for the past 10 years to attract new development to no avail. In addition, some older laid-off workers are pessimistic that the funds for retraining will be of use to them, since there are no jobs, other than in the fishery in isolated outposts like Grand Bank, Newfoundland. Others say that they have worked in the fishery too long to learn new skills.

Canadian union leaders also expressed their apprehensions. Larry Wark, regional representative of the Canadian Auto Workers Union (CAW) voiced his concern over the government's intention to reduce the number of workers in the industry. Wark fears that when the cyclical fishery eventually rebounds, there will be too few fishermen and too few processing plants. His union colleague, Rick Cashin, President of the CAW-affiliated Newfoundland Fishermen's Union, however, took a different view. Cashin echoed Valcourt's sentiments on the need for scaling back the industry, saying that there have been too many people who have turned to the fishing industry as a means of getting social benefits to the detriment of those who have been in the industry over the long-term.

Regional politicians also criticized the aid program. Newfoundland Premier Clyde Wells said that there was not enough money for economic development, or income support for fishery workers. Nova Scotia Premier John Buchanan expressed his disappointment with the package since he was looking for more funds for economic diversification. While, at first glance, most seemed disappointed with the aid deal, others are waiting to find out the exact details of the various programs before voicing their reaction. Many connected the fishery seemed ready with their criticism the instant the aid package was announced. Expectations for the package were high, perhaps unrealistically so. Given comments made by the industry and politicians before the announcement, it is unlikely that any assistance provided by the government would have been acceptable. The bottom line is that most fishermen in Atlantic Canada want the fishery to be like it was 3 years ago (when it was prosperous), while the Federal Government believes that change is essential if the industry is to survive. (Source: IFR-90/31.)

What Future for the Billfishes?

In August 1988 the Second International Billfish Symposium was held in Kailua-Kona, Hawaii, in conjunction with the Thirteenth Annual Marine Recreational Fisheries Symposium. The proceedings for part I, on the fishery and stock synopses, data needs, and management considerations, has been published as Marine Recreational Fisheries 13, entitled **"Planning the Future of Billfishes, Research and Management in the 90s and Beyond,"** by the National Coalition for Marine Conservation, P.O. Box 23298, Savannah, GA 31403. The first international billfish symposium was held in 1972.

The material is presented as five separate panel presentations, plus a debate on the various approaches to billfish management. The first panel includes five articles on fisheries trends for the various species of billfishes in the Atlantic, Pacific, and Indian Oceans, and two on the economic trends affecting commercial and recreational billfish fisheries. These provide good historic reviews of the various fisheries up to about 1985-86.

Panel two includes five articles assessing the condition of billfish stocks and the quality of stock assessment work. The third panel was devoted to identifying the biological, statistical, and economic data needed for management, while the fourth one reviewed and critiqued national and international strategies for managing billfishes and other highly migratory fishes. Following the debate session, the fifth panel was a summarizing session, "future prognosis and recommendations." Overall, the volume is a fine assessment of the status of knowledge about the various billfishes and their management which also points out areas where more data and research are needed. Hardbound, the 361-page volume is sold by the NCMC for $31.50 postpaid.

Advancements in the Culture of Tilapia

"The Second International Symposium on Tilapia in Aquaculture," edited by R. S. V. Pullin, T. Bhukaswan, K. Tonguthai, and J. L. Maclean, has been published by the International Center for Living Aquatic Resources Management, MC P.O. Box 1501, Makati, Metro Manila, Philippines, as ICLARM Conference Proceedings 15. The huge volume includes 82 papers and 17 poster abstracts divided into the following sessions: Culture systems, management and production; pathology; genetics and reproduction; nutrition; physiology; biology and ecology; and economics and socioeconomics. The symposium was held in March 1987 in Bangkok, Thailand, and the third such symposium is scheduled for an African location, probably Côte d'Ivoire, in 1991.

The volume itself reflects an accent on the improvement of tilapia breeds and culture systems in many different nations; more papers were presented on aspects of genetics and reproduction than the other topics. Research results are presented on studies ranging from relationships between primary production and yield of tilapia in ponds, polyculture of tiger shrimp and Nile tilapia, role of tilapia in integrated farming systems, to the effect of predation by *Lates niloticus* on overpopulation of tilapia in ponds, energy budgets for cultured tilapias, and major diseases encountered in controlled environment culture of tilapias in fresh- and brackishwater in Arizona.

Reproductive studies included gonadal sex differentiation in *Oreochromis niloticus*, bidirectional-backcross selection for body weight in a red tilapia, viability of red and normal-colored *O. aureus* and *O. niloticus* hybrids, breeding characteristics and growth performance of Philippine red tilapia, use of electrophoresis for identifying and control of tilapia breeding stocks in Israel, production of sex-reversed Nile tilapia fingerlings in the Philippines, cold tolerance and growth of three strains of *O. niloticus*, and others.

Other papers discuss protein biosynthesis in circulated fishponds, a comparison of natural feeding and supplemental feeding of pellets in *O. niloticus* cage culture, evaluation of fixed and demand feeding regimes for *O. aureus* cage culture, salinity tolerances of red tilapia, cannibalism among different sizes of *O. niloticus*, aluminum toxicity to tilapias, Philippine tilapia economics, and much more.

Hardbound, the 623-page reference is sold by ICLARM (airmail) at $45 (paperback) of $58 (hardback) or, in North America, by International Specialized Book Services, 5602 Hassalo St., Portland, OR 97213-3640, or, in Europe, by S. Toeche-Mittler GmbH, Versandbuchhandlung, Hindenburgstrasse 33, D-6100 Darmstadt, Federal Republic of Germany, at the same prices.

Fisheries Management and Extended Jurisdiction

Publication of **"Management of World Fisheries,"** subtitled "Implications of Extended Coastal State Jurisdiction" and edited by Edward L. Miles, has been announced by the University of Washington Press, P.O. Box 50096, Seattle, WA 98145-5096. The volume constitutes the proceedings of a workshop organized by the World Fisheries Project, Institute for Marine Studies, College of Ocean and Fishery Sciences, Univer-

sity of Washington, Seattle, and held 8-11 July 1985.

During the last 10-15 years many changes have occurred in the world's fisheries and their management, particularly relating to the extension of authority of coastal nations over their resources to 200 miles. This volume provides a good look at those changes and an assessment of their effect and implications for the improvement of fisheries management in the future. The contributions, by recognized fisheries authorities, are divided into three parts. Papers in Part I present an overview of the effects of extended fisheries jurisdiction on the management of fish stocks, including a comparison of the effects in a region under the open-access regime with regions under EFJ. Part II evaluates in more detail the trends that have occurred in six regions: Northeast Atlantic, East Central Atlantic, Northeast Pacific, Northwest Pacific, West Central and Southwest Pacific, and the East Central and Southeast Pacific.

Finally, in Part III, J. A. Gulland, Robert Kearney, and Edward Miles present their views on whether and how fishery management might be improved under EFJ. Some of the conclusions include managing fisheries by objective (indeed defining fishery management objectives); define national net benefit for fisheries; elaborate in more detail the nature of authority needed to make timely decisions and take effective action; define specific management alternatives and evaluate their probable consequences; and others. Indexed, the 318-page hardbound volume is sold by the publisher for $30.00.

A Global Dictionary of Important Fishes

The **"Five-Language Dictionary of Fish, Crustaceans and Molluscs"** by Willibald Krane had been published by Van Nostrand Reinhold, 115 Fifth Avenue, New York, NY 10003, under the AVI imprint. While the book does not provide definitions, it does present a lengthy and cross-referenced listing of the names of more than 2,000 commercially important fishes and primary fish products in five different languages (English, German, French, Spanish, and Italian), as well as the appropriate Latin or scientific names. In addition, there are five corresponding language indexes and a scientific name index to help the user locate the appropriate name of the particular species or product.

The author was chief chemist and head of the Nordsee Deep-Sea Fisheries central laboratory in Bremerhaven, and the book seems to have a European cast to it which does not always follow the common names given in the American Fisheries Society's special publication on common names of fishes. Still, by cross checking the reader should be able to find what he or she is looking for, particularly for the non-American fishes.

In the main section of the book (p. 13-259), the names or terms are arranged in alphabetical order according to the key word in English. Readers are advised to look up first the name or term sought in the alphabetical index of the particular language. Each primary entry is numbered, and in each language the primary name or wording is listed first, followed by those names used in particular regions or which are less common or unofficial names.

Under the term "common," for example, over 50 species are given in the English index, ranging from "common American squid" to "common whitefish." A number of marine mammals are also listed, including various whales, sea otter, etc. In another example, the John Dory has at least four listings, once with just the family name Zeidae, under the A's as "American John Dory," with the Latin name *Zenopsis ocellata*, and also with the Latin name *Zeus japonicus*. Hardbound, the 476-page volume costs $69.95, and it should help fish processors, buyers, and others involved in the fish trade to find out what fish or product they are interested in.

Counting the Whales

Publication of **"The Comprehensive Assessment of Whale Stocks: The Early Years,"** edited by G. P. Donovan, has been announced as Special Issue 11 of the International Whaling Commission, The Red House, Station Road, Histon, Cambridge CB4 4NP, U.K.

Work on defining, identifying, and accomplishing a "Comprehensive Assessment" of whale stocks has been in progress for nearly a decade and this volume presents the results of the initial steps via a series of reports of workshops and meetings, reviews and studies, and papers that describe potential or proposed management procedures.

Among the reviews published are survey techniques for estimating cetacean abundance, molecular techniques for examining genetic variation and stock identity in cetaceans, and an analysis of Southern Hemisphere minke whale mark-recovery data. Finally, five papers are presented on various aspects of the regulation of whale stocks and the setting of catch quotas which help to document the progress up to about 1988-89. Hardbound, the 210-page volume is available from the IWC at £25.00 ($45.00) plus £5.00 ($8.00) for postage and handling.

A Review of European Maritime History

Publication of **"European Naval and Maritime History, 300-1500"** by Archibald R. Lewis and Timothy J. Runyan has been announced by the Indiana University Press, Tenth & Morton Streets, Bloomington, IN 47405. The authors are professional historians; Lewis is editor of *The American Neptune* and Runyan has edited "Essays in Maritime History." Specifics on maritime history in the earlier centuries are few, but this volume provides a good review of and perspective on what is known, particularly about vessel development and use, commerce, and naval tactics during the medieval era—a time of growing importance of maritime trade and naval strength.

The authors begin with the late Roman world (up to A.D. 500), then move into a discussion of Byzantine, Muslim, and Latin western naval power and shipping/commerce in the Mediterranean region during about 500-1500. They then discuss the Irish, Frisian, and Viking roles in the northern seas during 500-1000. Then they review the rise of the English and Iberian sea power.

While much of the book reflects naval

advances and activities, the rise of the fish trade in the latter centuries is also documented, along with the rise of the Hanseatic League, cities bordering the North Sea, which drew strength from its monopoly of the Baltic herring trade and salt supplies for herring and cod preservation. Also mentioned is the extension of fishing to North American waters by the late 1400's, plus technological developments such as the increasingly larger merchant and fishing vessels in the North Atlantic and other improvements in vessel design, such as the multimasted Netherlands-North Sea herring buss of the 1500's with frame-first construction.

Also examined are the historic relationships between sea power, economic development, and commercial interests, including development of trade in marine resources. Thus, the book is a fine synthesis of early and modern writing on the medieval naval and maritime legacy, combined with recent underwater archaeological findings. Indexed and well illustrated with maps, photos, and drawings, the 192-page volume is available at $9.95 (paper) and $22.50 (cloth).

Angling Annual and Records Published

The 1990 edition of **"World Record Game Fishes"** has been published by the International Game Fish Association, 3000 East Las Olas Blvd., Fort Lauderdale, FL 33316-1616, and contains a new series of articles, along with the annual angling records of considerable interest to sport fishermen. Articles this year report on angling off Baja California, Mexico, and British Columbia and Labrador, Canada. Also included is a rating of "99 of the world's best fishing holes" by noted angling writer A. J. McLane; a look at Michigan's effort at producing trophy size "triploid" chinook salmon by Don Garling and Howard Tanner; and angling for dorado, *Salminus maxillosus* and *S. brevidens*, in Argentina's Parana River.

As usual, Section 4, the updating of IGFA's "world records" for freshwater and saltwater trophies and fly fishing catches will be of interest to many readers. In addition, Section 6 lists the 14th annual fishing contest winners and members of the 5, 10, 15, and 20-to-1 clubs, plus the 1,000-pound club members—that is, those anglers taking fish that weigh 5, 10, etc. times the breaking strength of their line and those taking fish weighing over 1,000 pounds, respectively. Also included is a section on IGFA's angling rules for records and contests, a guide to sport fishes around the world, and appendices on worldwide gamefish record-keeping organizations, state record-keeping agencies, worldwide tag-and-release programs, and more. An annual contribution to IGFA of $20 (U.S.) and $30 (all other nations) entitles the donor to both IGFA membership and a copy of the annual publication, as well as a bimonthly newsletter *The International Angler*, among other services.

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Editorial Guidelines for the *Marine Fisheries Review*

The *Marine Fisheries Review* publishes review articles, original research reports, significant progress reports, technical notes, and news articles on fisheries science, engineering, and economics, commercial and recreational fisheries, marine mammal studies, aquaculture, and U.S. and foreign fisheries developments. Emphasis, however, is on in-depth review articles and practical or applied aspects of marine fisheries rather than pure research.

Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

The Manuscript

Submission of a manuscript to *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under a completed NOAA Form 25-700.

Manuscripts must be typed (double-spaced) on high-quality white bond paper and submitted with two duplicate (but not carbon) copies. The complete manuscript normally includes a title page, a short abstract (if needed), text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). Manuscript pages should be numbered and have 1½-inch margins on all sides. Running heads are not used. An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

Abstract and Headings

Keep titles, heading, subheadings, and the abstract short and clear. Abstracts should be short (one-half page or less) and double-spaced. Paper titles should be no longer than 60 characters; a four- to five-word (40 to 45 characters) title is ideal. Use heads sparingly, if at all. Heads should contain only 2-5 words; do not stack heads of different sizes.

Style

In style, the *Marine Fisheries Review* follows the "U.S. Government Printing Office Style Manual." Fish names follow the American Fisheries Society's Special Publication No. 12, "A List of Common and Scientific Names of Fishes from the United States and Canada," fourth edition, 1980. The "Merriam-Webster Third New International Dictionary" is used as the authority for correct spelling and word division. Only journal titles and scientific names (genera and species) should be italicized (underscored). Dates should be written as 3 November 1976. In text, literature is cited as Lynn and Reid (1968) or as (Lynn and Reid, 1968). Common abbreviations and symbols such as mm, m, g, ml, mg, and °C (without periods) may be used with numerals. Measurements are preferred in metric units; other equivalent units (i.e., fathoms, °F) may also be listed in parentheses.

Tables and Footnotes

Tables and footnotes should be typed separately and double-spaced. Tables should be numbered and referenced in text. Table headings and format should be consistent; do not use vertical rules.

Literature Cited

Title the list of references "Literature Cited" and include only published works or those actually in press. Citations must contain the complete title of the work, inclusive pagination, full journal title, and the year, month, volume, and issue numbers of the publication. Unpublished reports or manuscripts and personal communications must be footnoted. Include the title, author, pagination of the manuscript or report, and the address where it is on file. For personal communications, list the name, affiliation, and address of the communicator.

Citations should be double-spaced and listed alphabetically by the senior author's surname and initials. Co-authors should be listed by initials and surname. Where two or more citations have the same author(s), list them chronologically; where both author and year match on two or more, use lowercase alphabet to distinguish them (1969a, 1969b, 1969c, etc.).

Authors must double-check all literature cited; they alone are responsible for its accuracy.

Figures

All figures should be clearly identified with the author's name and figure number, if used. Figure legends should be brief and a copy may be taped to the back of the figure. Figures may or may not be numbered. Do not write on the back of photographs. Photographs should be black and white, 8 × 10 inches, sharply focused glossies of strong contrast. Potential cover photos are welcome, but their return cannot be guaranteed. Magnification listed for photomicrographs must match the figure submitted (a scale bar may be preferred).

Line art should be drawn with black India ink on white paper. Design, symbols, and lettering should be neat, legible, and simple. Avoid freehand lettering and heavy lettering and shading that could fill in when the figure is reduced. Consider column and page sizes when designing figures.

Finally

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